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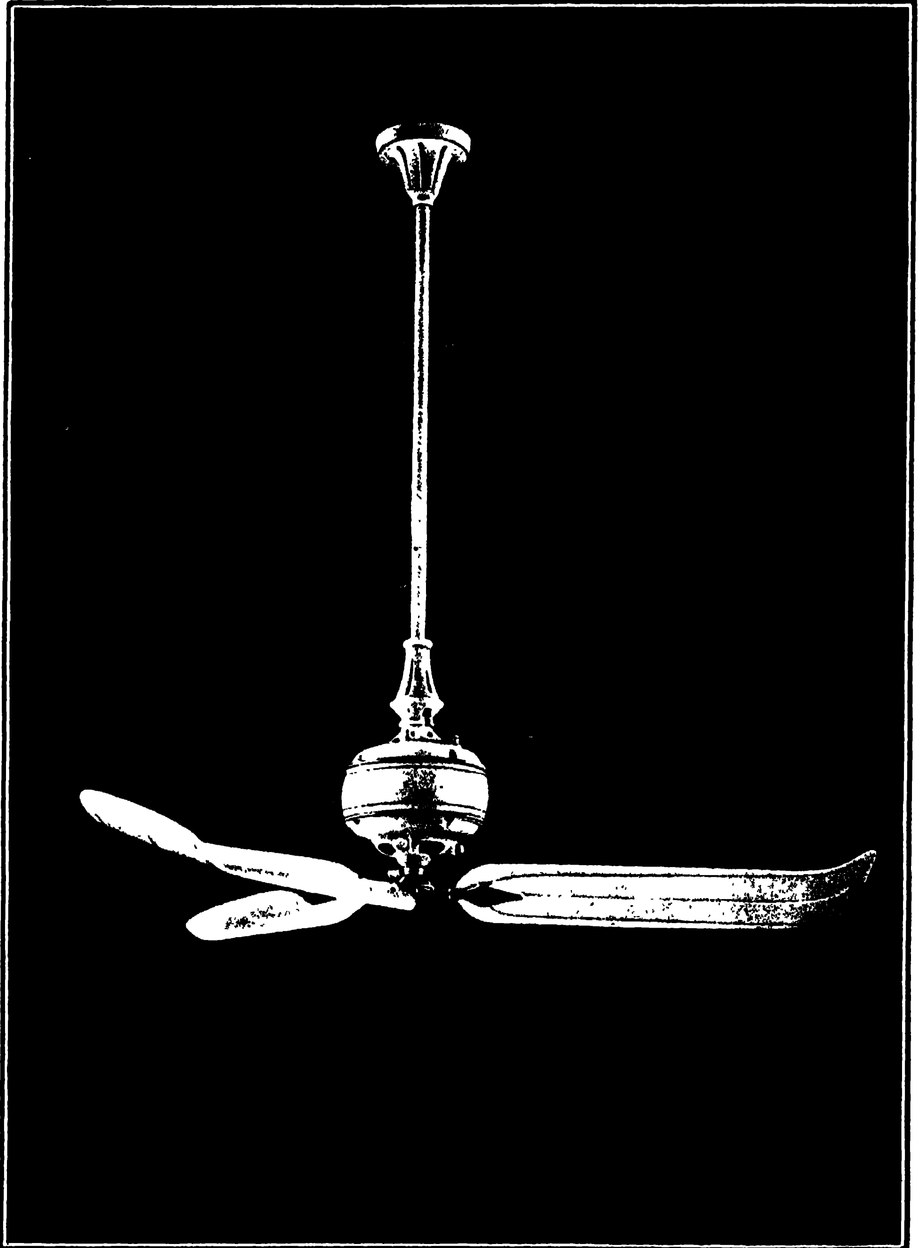
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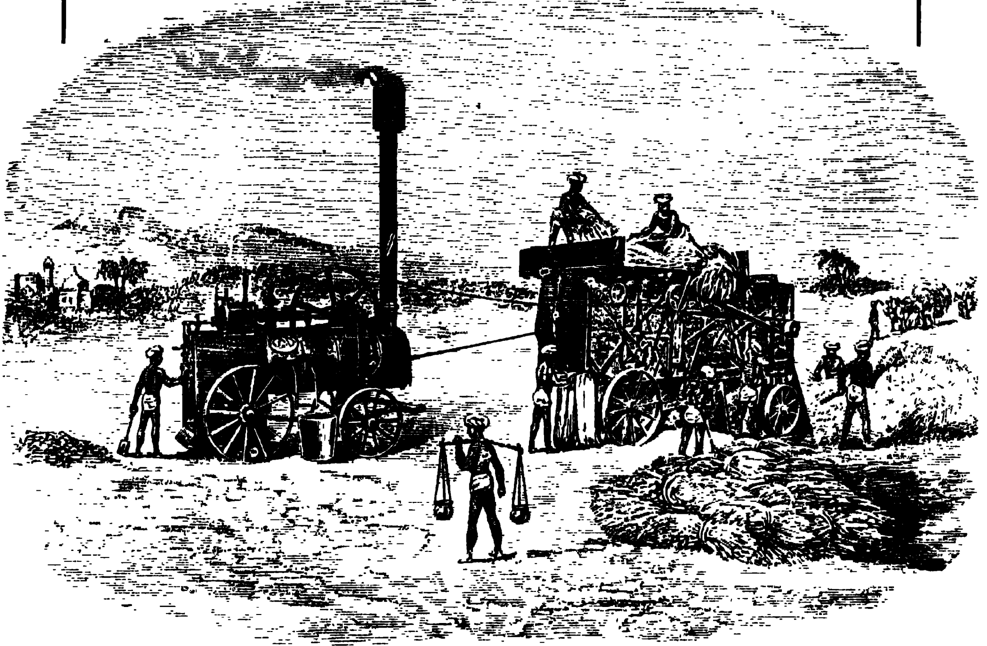
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EDITORIAL.

REGULAR readers of the Journal will notice many changes in this number which marks the commencement of a new series.

It is with particular pleasure that we inaugurate this series with a photograph of His Excellency the Viceroy. On every public occasion on which he has had an opportunity—in Simla, Mandalay, and Calcutta His Excellency has expressed a keen personal interest in the agriculture of the country, and his sympathetic references are of the greatest encouragement to those who are engaged in furthering the work. We feel confident that with this marked sympathy agriculture will make great progress in India during Lord Chelmsford's Viceroyalty.

For the new features of the Journal we make no apology. Our "Selected Articles," we trust, will be of interest to the general reader and to those who, though they may take many agricultural papers, have not the time to read them. Secondly, our "List of New Books" may perhaps bring to the notice of our readers the names of books which may not have come before them. Personal notices will serve to keep the various members of the Department in touch with each other. Our object is to make the Journal an active link between agriculturists, veterinary officers, and co-operators, and we rely with confidence on a steady flow of support from them all. We particularly welcome an article from the senior member of the Civil Veterinary Department Col. Pease of the Punjab Veterinary College—and we trust that many members of his service will follow the example he has set, and contribute to the Journal.

As a word of warning and a disarmament of criticism we would remark that the Journal will not appear on the first of the month but *some time* during January, April, July, and October. Little unforeseen difficulties arise --such as the reproduction of a plate—which induce us to emphasize this latitude so as to protect ourselves from charges of unpunctuality.

Finally, we are not by profession journalists or editors, and we shall welcome all criticisms and suggestions. None will be deemed unworthy of consideration, and all suggestions of value will be acted on. This Journal is the Journal of the Agricultural Departments—not that of the Editor alone. Co-operation is our motto.

Fiscal Figures

ABOUT

Nitrate of Soda

Whether at the front or behind the line NITRATE of SODA is equally popular. Note the increased consumption in India, then try it on any plant that is a **SPERMAPHYTA** and you will know the reason why.

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Supplement to the Agricultural Journal of India,
January 1917.

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HIS EXCELLENCY THE VICEROY ON AGRICULTURAL PROGRESS.

In his opening speech at the meeting of the Imperial Legislative Council on 5th September, 1916, His Excellency the Viceroy spoke as follows :—

The activities of the departments administered by the Department of Revenue and Agriculture have also been restricted both by the need for economy and by the shortage of officers. Not only have the services of a considerable number of officers been placed at the disposal of the military authorities, but it is at present difficult to obtain suitable recruits, especially for the Forest and Agricultural Departments. We have lately, however, been able to secure the services of two experts from Home to conduct special investigations. One of these is studying the problem of reviving the trade in natural indigo. If he can devise a means of standardising the natural product in a form which will enable it to compete with the German synthetic dye, it is to be hoped that the planters will adopt some co-operative system of manufacture and marketing and thus place this once profitable industry on a sound basis for the future.

A tannin expert has also recently arrived with a small extract plant, and is engaged on an investigation of the tanning materials yielded by various forests in India, with a view to preparing tannin extracts for trial on a commercial basis. If his researches are successful, not only will the Forest Department obtain a new source of income, but the tannin industry may be expected to develop on a large scale, and to produce good leather from the enormous quantities of hides which are at present exported from India in a raw condition.

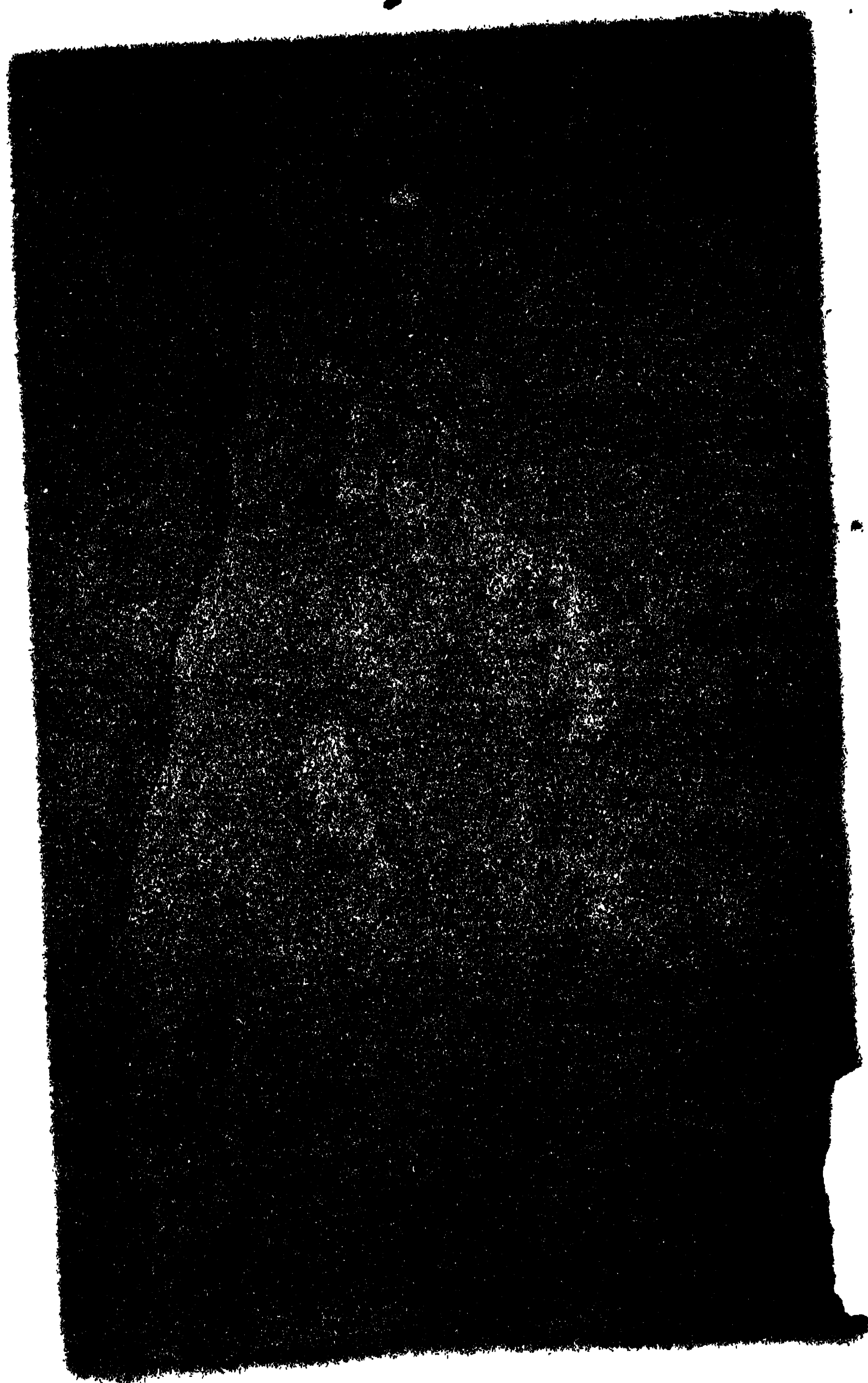
Mr. Lefroy's inquiries into the silk industry were interrupted by a visit to Mesopotamia, where he did valuable work in organizing

measures for the destruction of flies and vermin, but he has now returned and resumed his investigations. It is hoped that they will result in a considerable revival of this historic industry. Without forestalling his report, I think I may say that he will show that large parts of the country, especially the submontane tracts, are suitable for the production of the silkworm, which cannot thrive in the arid heat of the plains. It is equally important to know the areas which are unsuitable, so that efforts to develop the industry may be concentrated in those tracts which offer the best prospect of success.

The Hon'ble Mr. Hill explained at the discussion of the Financial Statement last March that the present period of comparative inactivity is being utilized for the preparation of schemes, especially in connection with agriculture, for development when more favourable conditions recur. It is my hope that those schemes will bear bountiful fruit during my term of office. The success of the researches at Pusa in selecting improved varieties of various crops, especially of wheat, has demonstrated the possibility of getting a vastly increased yield from indigenous species. There is room for many more workers in this field, and in course of time every large province should have a competent staff to work out local problems. There is equal room for expansion in the work of demonstrating the results of these researches. The Indian cultivator has shown himself quite ready to adopt improved methods as soon as he is convinced of their utility, and I look forward to a time when demonstration farms will be spread all over the country bringing the practical results of scientific research within the reach of the agricultural masses.

The improvement of agriculture, besides bringing prosperity and content to the majority of the population of India, will provide a worthy career for the young educated Indian who desires to serve his country, but does not always find the best way of doing it. The recommendations of the Conference on Agricultural Education, over which the Hon'ble Mr. Hill presided last February, have been considered by Government, and have recently been referred for the opinions of Local Governments. The Conference dealt, among

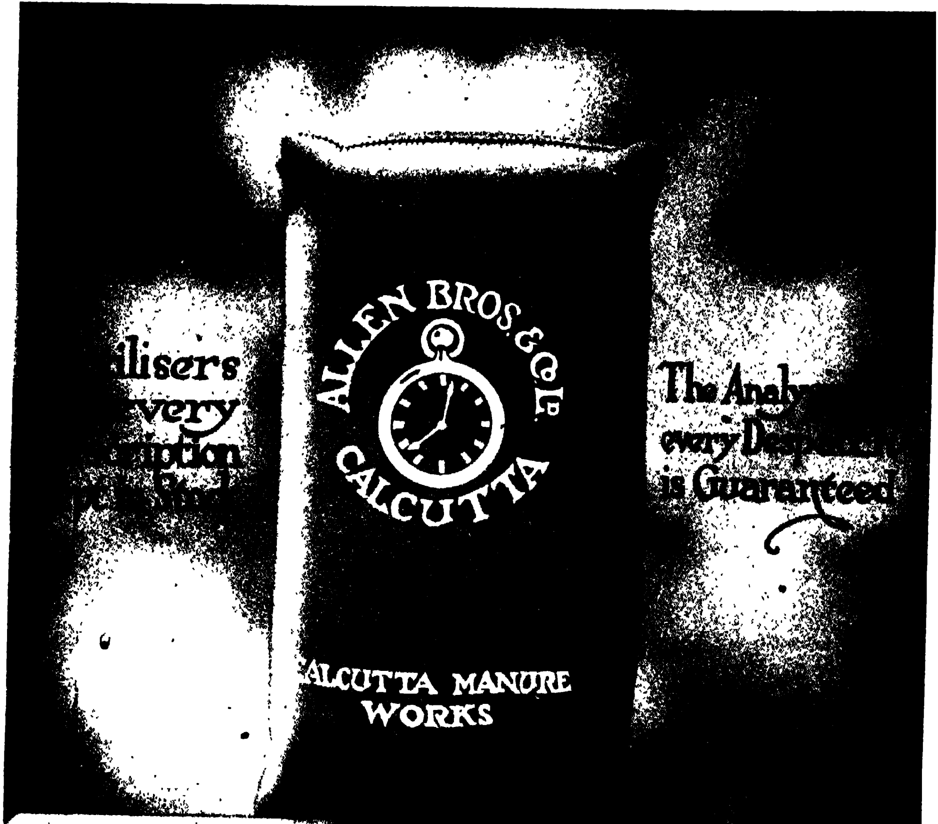
His Excellency Lord Chelmsford
Viceroy and Governor General of India



other matters, with the question of reforming the system of education in our agricultural colleges. One of the chief needs of those colleges is to attract suitable students. The development of agricultural farms should tend to effect this object, but more farms can only be opened as men become available to manage them, and agricultural education and development are thus interdependent. I should like from my personal experience in Australia to lay stress on this. Agricultural colleges and demonstration farms have played a great part in the development of the agricultural industry in that country ; and though the farming community is notoriously conservative, it has through these means been awakened to the possibilities opened out by science. I should like to impress this further fact on Indian parents when they are planning the future of their sons, they might well pause to consider whether, instead of sending them to join the overstocked market of the legal and literary professions, it would not be better to turn their attention to the possibilities of employment in scientific agriculture. As the department expands, it will afford greater opportunities of advancement, and the man who elects for this service may do well for himself and at the same time contribute to the prosperity of his country.

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CONTENTS



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Original Articles.

TEN YEARS' PRACTICAL EXPERIENCE OF JAVA INDIGO IN BIHAR.*

BY

THE HON'BLE MR. D. J. REID,

Belsund Concern, Bihar.

THE Java variety of Indigo, *Indigofera arrecta*, was first sown in 1904 at Belsund Concern. This Concern is situated in the Sitamarhi Sub-division of Muzaffarpur District, and lies about six miles north of the Bagmuttee river. Sitamarhi Sub-division is in the north of the district, and the character of the soil in this Sub-division is very different to that of the southern portions of the district. This is due to the fact that being closer to the hills, the periodical inundations from the rivers leave a deposit of silt of a beneficial nature, which preserves the fertility of the soil. The drainage, too, of this part of the district is better than further south, and the land is not so liable to waterlogging, there being a fall of about one foot per mile in the natural level of the country. Java indigo therefore develops a more luxurious growth than in the poorer soil of the southern portions of the district. With the Sumatrana variety of indigo this luxurious growth was not always an unmixed blessing, as experience proves that the more luxurious the growth of this variety, the smaller the yield of finished indigo per unit of green plant. This disadvantage, however, is not so marked in the

* Received for publication on the 25th July, 1916.

Java variety due possibly to the fact that it is a slower growing plant than the Sumatrana, and even in the strongest of lands it has time to develop a full yield of indican before coming to maturity.

The area sown in 1904 at Belsund was only about 32 acres, but the cultivation was rapidly increased, and in 1907 an area of about 2,000 acres was sown, which area has been more or less maintained up to the present season.

The following is a detailed account of each season's working with the rainfall records, and notes have been added of the features of the season from records in existence at Belsund Concern.

The results given are calculated on the bigha, and as the bigha varies in size in different localities, it should be noted that the bigha at Belsund Concern is about seven-eighths of an acre. It will also be observed that the area of Second Cuttings is invariably less than the area of First Cuttings. This is due to the fact that a certain proportion of the first cuttings are from low lands, which are never kept for second cuttings. In seasons 1904-5 and 1905-6 the Java variety of indigo was only sown at Belsund Head Factory, but in 1906-7 the cultivation was extended to Bhagwanpur Out-factory of which separate records are given. Bhagwanpur Out-factory is eight miles distant from Belsund Factory.

JAVA INDIGO.

SEASON 1904-5.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo			Produce per bigha	
			Mds.	Srs.	Chtks.	Srs.	Chtks.
1st ..	June 21st to 25th	33½	8	21	8	10	3
2nd	September 7th to 9th	29	4	18	4	6	2½
			TOTAL ...			16	5½

Rainfall 1905.

Date	May	June	July	August	September
	Inches	Inches	Inches	Inches	Inches
1 ...	...	...	...	2·55	0·41
2 ...	...	2·00	...	1·11	...
3 ..	0·62	...	...	...	...
4 ...	...	...	2·48	...	...
5 ...	0·39	0·61	...	0·23	...
6 ...	...	...	...	2·51	...
7 ...	...	...	.	0·15	...
8 ...	0·65	0·22	...	0·31	...
9 ...	...		..	2·61	0·23
10 ...	...	...	...	2·41	...
11 ..	...	..	0·15	0·28	..
12	...	...	...	...	0·12
13 .	...	...	...	..	...
14 ..	...	...	1·19	2·51	0·15
15 ...	...	..	0·73	0·75	0·15
16 ...	...	...	4·11	1·61	0·11
17 ..	...		0·15	...	1·41
18 .	.	...	0·25	..	2·35
19 ..	..	0·65	0·21	..	.
20 ..	.	0·55	...	0·45	...
21 ...	.	...	..	...	.
22 .		...	..	...	.
23	..	0·65	...	0·10	
24 .	.	...	..	0·75	..
25 .	1·75	0·38	..	...	.
26 . .	.	...		...	..
27 ..	.	.	1·05	...	...
28	...	...	2·11	3·41	9·15
29 .	.	...	3·21	1·38	1·51
30	.	...	1·81	0·41	.
31 ..	...	...	0·71	1·81	
TOTAL ...	3·41	5·06	18·16	25·34	15·59

TOTAL, May to September = 67·56 Inches.

Extracts from the "Press Copy Book," Belsund Concern.

Extract from letter to Mr. J. Macdonald of Portree Skye.

Dated Belsund, August 8th, 1905.

NATAL-JAVA.

It is wonderful the way this plant resists rain. Some of the Khunties here have had 2 ft. of water in them, and though, of course, the lower leaves have died the upper leaves that escaped the water are quite green and show no yellow. Other of the Khunties that had six inches of water are perfectly green and have not turned yellow at all.

Extract from letter to Messrs. Begg, Dunlop & Co., Calcutta.

Dated Belsund, August 20th, 1905.

NATAL-JAVA INDIGO.

The vitality of this plant is extraordinary. Some plant that had been standing in water for nearly a couple of weeks has, now that the water has subsided, begun to sprout again.

Extract from letter to the late Mr. L. J. Crowdy, Ramsgate.

Dated Belsund, September 6th, 1905.

NATAL INDIGO.

This is a wonderful plant, some flooded Khunties which I cut actually gave a return of three seers per bigha. The ordinary plant would not have given a single leaf. I hope to have 400 bighas next year. We have had over 60 inches rain now; if the weather does not clear I am afraid that the *rabi* crop will be spoilt from over-moisture.

Extract from letter to Messrs. Begg, Dunlop & Co., Calcutta.

Dated Belsund, September 12th, 1905.

NATAL-JAVA INDIGO.

I had 36 bighas of this plant this year, I beg to submit the following report.

Out of the 36 bighas, 6 bighas have been reserved for seed. The remaining 30 bighas were sown in two fields of about 15 bighas each, one field being of a clayey description of soil low lying and of rather poor quality. The other field had been manured two years ago, and was of a light sandy soil.

The low-lying field has given a return of about 12 seers of indigo per bigha of 9½ ft. luggee. The sandy field has given a return of 22 seers per bigha, average return of 30 bighas being about 17 seers. The Khunties in the first field were badly flooded, hence the poor return in comparison to the second field.

I was very surprised to find that the abnormal rain that we have had made no bad effect on the produce from the plant. In fact the produce per 100 mds. of green plant was better during Khuntie *mahai* than during *mohrun*.

The Season of 1904-5 was the first season Java indigo was cultivated in the Belsund Concern. The seed was pounded with broken bottles for scarification, and sown in small lots during August, September and October 1904. The year 1905 was one of very heavy rainfall. The extracts from the Belsund Press Copy Book lay very great stress on the surprising fact that this heavy rainfall had very little bad effect on the plant. There was absolutely no sign of the "Wilt" disease, and the *mahai* Records of the succeeding season 1906 show that this plant was retained for another year, and gave a yield of 5 seers 7 chtks. per bigha from the first cuttings.

The seed yield also was extraordinarily heavy, as much as 15 mds. per acre having been obtained from the uncut plant which was retained for seed purposes.

The photographs here reproduced bear out these statements. Fig. 1, Plate I, shows the uncut plant which was retained for



Fig. 1.
Java Seed Indigo. Belsund, October 1905.
Seed Yield-Mds. 15 per acre.



Fig. 2.
Java Indigo 1st Cuttings.
Belsund, June 21-25, 1905.



Fig. 3.
Java Indigo 2nd Cuttings.
Belsund, September 7-9, 1905.

seed, and was taken in October 1905. It can be observed that the plant is fully seven feet high, and this after a deluge of 67·56 inches from May to September. It may be also added that this particular field has been in Java indigo several times subsequently and has never grown plant higher than 3 to 4 feet, and has always developed wilt. Fig. 2, Plate I, shows the plant being cut on June 21st to 25th for manufacture. It will be observed that the plant is about 6 feet high. Fig. 3 shows the same field being cut 2½ months later, September 7th to 9th for second cuttings after receiving a deluge of 44 inches rain during the interval.

JAVA INDIGO.

SEASON 1905-6.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo	Produce per bigha
			Mds. Srs. Chtks.	Srs. Chtks.
st	June 20th to 25th and July 4th to 6th and 29th to August 1st.	289	68 16 4	9 7½

Rainfall 1906.

	Inches
May	2·33
June	8·29
July	14·63
August	28·90
September	5 61
TOTAL	59·76

Extracts from the "Press Copy Book," Belsund Concern.

Extract from letter to Mr. J. Macdonald of Portree Skye.

Dated Belsund, June 25th, 1906.

NATAL.

My last year's crop has only given about 6 seers per bigha, but I kept the crop for seed instead of cutting it back in February with the result that it was overmature, and had lost most of its leaf, before it was put into the vats.

TRANSPLANTING.

I am afraid that this is not a success; the plants have not grown well, and are smaller than the sowings.

I am now manufacturing from the October sowings and getting between 11 to 12 seers per bigha. This return, however, will not be maintained as some of the crop is too thin due to the bad seed we got last year.

Extract from letter to Mr. J. Macdonald of Portree Skye.

Dated Belsund, July 24th, 1906.

The Natal-Java Khuntios are coming on well and should give almost as good a return as the *mohrun.*

In Season 1905-6 the experiment of transplanting the young Java plants was tried, but it was not a success, the sown crop was also a poor one due to the inferior seed which was obtained from Java. All these circumstances considered, the return of 9 seers 7½ chtks. per bigha for first cuttings was a good one. Unfortunately a very heavy flood in August wiped out the second cuttings, though the records show that on July 24th these cuttings were very promising.

The uncut plant which was retained for seed purposes gave a yield of 8 mds. per bigha as compared to 13 mds. of the previous year.

JAVA INDIGO.

Season 1906-7.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo			Produce per bigha	
			Mds.	Srs.	Chtks.	Srs.	Chtks
1st	May 30th to June 27th ..	666	172	31	8	10	6
2nd	July 1st to Aug. 21st ..	645	160	23	12	9	15
3rd	Sept. 8th to 20th and Oct. 20th to 26th	303	21	14	4	2	13
				Total		23	

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st .	June 7th to 25th ..	133	42	18	12	12
2nd ..	Aug. 10th to 23rd .	117½	44	16	15	2
3rd ..	Oct. 19th to 24th ...	53	11	14	8	9
			Total ...		36	7

Rainfall 1907.

Date	May	June	July	August	September
	Inches	Inches	Inches	Inches	Inches
1 ...	...	...	0·31	0·81	0·15
2 ...	...	..	0·55	...	0·81
3 ...	.	...	0 31	...	2·11
4 ...	..	...	0·31	...	0·05
5 ...	...	..	...	...	4·71
6 .	..	...	...	..	0·31
7 .	..	. .	1·41	...	1·00
8 ...	.	..	...	.	...
9 ...	...	...	...	.	...
10 ...	...	..	...	.	0·15
11 ...	.		...	..	2·05
12 .	...	.	..	0·21	...
13 .	...	...	...	...	...
14 ..	..	0 71	0·21	...	...
15 .	.	...	1·11	...	0·05
16 .	...	0·35	1 25	0·15	...
17 .	..	3·00	0·81	.	...
18	0·05	. .	0·11	...	..
19 .	...	2·91	0·31	...	..
20 ..	..	1·25	...	0·31	3·00
21	...	...	..	..	...
22	...	1·61	...	0·51	0·45
23	0·05	...	...	...	...
24 .	..	...	0·11	0·71	..
25	..	0·31	0·45	0·15	..
26	...	...	0·11	...	...
27 .	0·15	..	...	...	.
28	0·21	...	...	1·15	.
29 ...	...	..	...	1·31	.
30 .	.	0·41	0·21	0·11	.
31	0·11	...	1·38	1·00	
TOTAL .	0·57	10·55	8·95	6·42	14·84

TOTAL, May to September=41·33 inches.

The yield for Season 1906-7 was exceptionally good, and third cuttings were obtained over a large area. This was the first season in which the Java plant was introduced at Bhagwanpur Factory, some of the lands in this factory giving a yield of 36 seers 7 chtks. per bigha, or over a maund of finished indigo per acre. It is needless to say that there was no sign of wilt in the plant that was cut for manufacture, but the uncut plant which was retained for seed gave a disappointing yield, and it is possible that wilt may have developed later in the season.

The total rainfall for the year was slightly below normal, and very evenly distributed.

SEASON 1907-8.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st	May 23rd to July 26th	1,334	288	7	8	10
2nd	August 1st to October 7th	1,191	285	34	9	9½
3rd	October 8th to 17th	233	30	26	5	4
			TOTAL		23	7½

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st	May 8th to August 6th	908	274	34	12	2
2nd	August 10th to 23rd and September 9th to October 16th	614	148	24	9	11
			TOTAL		21	13

Rainfall 1908.

		Inches			Inches			Inches			Inches			Inches
ay	5th	0·11	June	1st	0·11	July	5th	0·11	Aug.	6th	2·31	›t.	1st	0·51
,,	6th	0·15		5th	0·62		6th	2·75	,,	8th	0·05	,	3rd	0·31
,,	9th	0·21		8th	0·61		7th	3·65	,,	10th	0·51	,	5th	0·51
,,	24th	0·21		21st	0·11		13th	0·45	,,	15th	0·15	,	6th	0·11
,,	27th	0·42					14th	2·15	,,	30th	0·51	,	7th	2·51
,,	30th	0·66					15th	1·71				,	8th	2·00
							18th	0·31				,	14th	0·15
												,	29th	2·11
TOTAL		1·76			1·45			11·13			3·53			8·21

TOTAL, May to September=26·08 inches.

This was a year of very short rainfall, the only considerable fall being from July 6th to 15th when 10·7 inches fell. The yield from both first and second cuttings was good; third cuttings also being taken over a small area, there was no sign of wilt. Bhagwanpur Out-factory could not take all its second cuttings owing to a dam which impeded its water for manufacture.

No uncut plant this year was retained for seed, but the yield from plant which had been cut once and retained for seed was very fair.

SEASON 1908-9.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st .	June 4th to Aug. 4th ..	1,559	195	36	5	0
2nd .	Aug. 5th to 6th and September 20th to 24th	269	6	32	1	0
			TOTAL	..	6	0

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st ...	June 1st to Aug. 2nd	945	141	24	6	0
2nd	Aug. 3rd to 4th and Sept. 6th to 7th	...	4	28	2	2¼
			TOTAL	..	8	2¼

Rainfall 1909.

Date	May	June	July	August	September
	Inches	Inches	Inches	Inches	Inches
1	...	0·04	1·42	...	.
2	.	0·63	0·71	...	
3 ..		0·11	0·35	...	..
4 .		..	...	0·21	..
5 ..	..	0·42	0·05	1·20	
6		0·41	1·30	1·81	...
7 ...	..	0·35	...	0·31	..
8 ...	..	2·71	...	1·20	...
9	.	1·25	..	0·71	0·55
10	..	0·42	...	.	...
11 .		0·44	...	..	..
12 ...	..	0·71	...	0·65	.
13 ...		0·20	...	0·21	...
14 .	.	...	...	...	...
15 ...	..	...	..	1·20	...
16 ...	..	1·59	..	0·74	..
17 ...	...	0·82	...	...	0·20
18 ...	...	0·72	...	2·18	.
19 ..	..	...	..	0·41	...
20	1·39	...	...	1·21	0·43
21 ...	...	...	6·60	0·30	.
22 .	...	..	0·80	...	0·11
23 ...	...	...	..	0·15	...
24 ...	...	...	...	0·25	0·20
25 .	...	..	...	0·90	0·21
26 ...	..	...	0·45	0·50	..
27 ...	1·35	0·11	...	0·55	...
28 ...	...	0·21	...	...	...
29 ...	..	0·22	0·71	...	1·10
30 ...	..	0·71	...	2·75	1·60
31 ...	...	..	...	0·70	...
TOTAL ...	2·74	12·07	12·39	18·14	4·40

TOTAL, May to September = 49·74 inches.

This year is remarkable. In the first instance a record hail-storm at the end of May did enormous damage to the plant, and subsequently wilt disease appeared in the Khunties, with the result that the return from second cuttings was very poor. The total rainfall for the period May to September is not so very much above normal, but the distribution was bad especially in June and August, when owing to continued small falls of rain the lands could never have been properly dry. This was the first year in which the wilt disease made its appearance in sufficient extent to affect the yield of indigo.

SEASON 1909-10.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st ..	May 17th to July 14th ..	1,606	281	20	7	1
2nd ...	July 15th to 26th and August 7th to 16th	507	81	35	6	7
			TOTAL ...		13	8

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st .	May 30th to July 17th ..	1,137	241	18	8	7½
2nd ...	July 18th to 23rd and August 8th to 15th	242	31	4	5	2
			TOTAL ...		13	9½

Rainfall 1910.

Date	May	June	July	August	September
	Inches	Inches	Inches	Inches	Inches
1 ...	...	0·15	0·20	...	1·00
2 ..	...	...	...	...	0·60
3 ...	...	0·55	...	..	1·00
4 ...	.	0 15	...	...	0·25
5 ...	...	...	...	...	0·20
Carried over ...	...	0·85	0·20	...	3·05

Rainfall 1910—(contd.)

Date	May	June	July	August	September
	Inches	Inches	Inches	Inches	Inches
Brought forward	...	0·85	0·20	...	3·05
6	0·81	0·12	...	...	...
7	...	...	...	0·30	...
8		...	2·25	...	0·10
9		..	...	...	0·15
10	...	0·40	...		...
11	.	...	0·95	...	..
12		...	...	0·10	...
13	..	1·51	0·10	...	0·25
14	...	1·10	0·20	0·50	1·50
15	.	1·00	0·20	...	0·70
16		...	...	0·25	...
17	..	0·45	...	1·90	0·25
18		0·31	0·90	0·20	...
19	...	0·15	0·40	0·25	.
20	..	...	...	...	...
21	...	...	0·20	0·45	.
22	...	1·21	0·61	...	1·60
23	...	0·85	1·30	0·15	
24	.	...	2·50	0·15	
25	.	...	2·60	...	
26	..	...	1·00	..	
27		...	1·80	0·11	...
28	2·11	...	5·00	...	..
29	...	0·11	0·60	2·10	..
30		2·30	...	0·10	..
31	...	...	.	1·00	
TOTAL	2·92	10·36	20·81	7·56	7·60

TOTAL, May to September = 49·25 inches.

A very heavy flood which came down from the hills at the end of July destroyed all the second cuttings. Up to that date Belsund Head Factory had been doing very well with its second cuttings, and there was no sign of the wilt disease.

SEASON 1910-11.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st	May 20th to July 21st	1,503	270	34	7	3
2nd	July 22nd to 26th and Sept. 1st to 6th	385	28	30	2	15
			TOTAL		10	2

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st	May 18th to July 13th ...	1,132	234	35	8	4½
2nd	July 14th to August 27th and Sept. 10th to 12th	877	193	3	8	12½
			TOTAL		17	1

Rainfall 1911.

Date	May	June	July	August	September
	Inches	Inches	Inches	Inches	Inches
1	..	...	3·30	...	..
2	..	...	...	..	0·20
3	.	..	...	0·35	...
4	...	2·00	...	...	...
5	..	...	...	..	...
6	..	1·22	3·00	0·10	...
7		0·30	..	0·15	0·45
8		.		1·90	...
9		...	.	0·25	0·10
10	.	.	...	0·85	0·15
11	..		.	..	...
12	..	1·00	.		.
13		0·11	...	0·65	0·70
14		...	0·50	2·30	7·70
15		...	2·45	0·25	.
16		..	0·90	0·40	...
17		0·10	0·50	0·30	.
18	.	..	...	0·30	0·75
19	.	0·85	...	...	...
20	.	..	...	0·65	...
21	...	0·15	0·30	0·25	...
22	...	...	.	0·15	...
23	0·10	...	.	0·20	0·30
24	..	5·00	...	0·20	.
25	...	0·15	.	...	0·10
26	2 00	..	0·15	..	...
27	..	...	...	0·50	
28	..	...	...	0·40	...
29		...	..	...	
30		.	2·75	..	..
31	...	.	0·20	...	..
TOTAL	2·10	10·88	11·05	10·15	10·45

TOTAL, May to September=47·63 inches.

The feature of this season was the fact that the second cuttings at Belsund Head Factory were badly attacked by wilt, while the Bhagwanpur Out-factory cultivation escaped, the distance between the two factories being about eight miles. Both factories conducted

their first cuttings at practically the same time, the yield from the first cuttings being seers 7/3 at Belsund and seers 8/4½ at Bhagwanpur, the weather conditions at both places being more or less similar. The total rainfall was slightly above normal, and the distribution during August was very unfavourable, there having been 19 days on which rain fell during this month. The rainfall, however, of June and July should have been favourable to the growth of the second cuttings, and that it was so at Bhagwanpur Factory is proved by the yield of seers 8/12½ per bigha as compared to a return of only seers 8/4½ from first cuttings. The second cuttings' return however at Belsund Head Factory was very poor; only bighas 385 giving any return at all, as compared to an area of bighas 1,503 cut for first cuttings. As both factories commenced their first cuttings in May the unfavourable weather conditions in August could not have affected the second cuttings.

Season 1911-12.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st	May 20th to July 23rd	1,470	180	1	4	14
2nd	July 23rd to August 11th .	778	40	6	2	1
			Total ..		6	15

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st ...	May 19th to June 29th ...	925	143	27	6	3
2nd ...	July 25th to August 9th ...	746	59	22	3	3
			Total ..		9	6

Rainfall 1911-12.

Date	Nov. 1911	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1		...	0·47	...	..	...	1·05	1·50	...	1·30
2		..	..				...	0·30	...	...
3							...	0·35	...	0·90
4							0·35	3·65	...	...
5							..	0·60	0·10	...
6							0·30	...	...	1·50
7							...	...	0·20	4·50
8								0·15	0·15	0·70
9							1·70	0·20	1·65	...
10		0·25						0·94	0·30	...
11								0·47	..	
12	0·10					..		1·20	...	
13	...					...		0·50	0·20	
14						1·80		...	...	
15					..		...	...	...	..
16					..		...	...	...	
17					0·85	...		0·30	1·05	
18					...	..		...	0·05	...
19					0·30		..	...	2·65	
20	0·65			...	...	0·85	0·35	0·10	...	..
21					0·95		...	...	...	
22					...		...	..	0·15	
23	..						0·30	...	...	
24				..			0·20	0·10	...	..
25				...			0·25	...	0·10	
26		..		..			..	0·25	..	
27				0·20				0·50	..	
28						..		...	...	
29				1·10		..				
30									..	..
31		..					..		..	...
TOTAL	0·75	0·25	0·47	1·30	2·10	2·65	4·50	11·11	6·60	8·90

TOTAL rainfall, May to September=33·76 inches.

Sunshine Record.

July	23 days with sun.		8 days without sun.	
August ...	30	do.	1 day	do.
September ...	27	do.	3 days	do.

Previous Season's Rainfall.

Total rainfall, 1911	52·23 inches.
September rainfall, 1911	10·45 ,,
October do.	3·00 ,,

Extracts from the "Press Copy Book," Season 1912.

Extract from letter to Messrs. Begg, Dunlop & Co.

Dated Belsund, July 27th, 1912.

Although weather conditions are favourable produce continues to be disappointing, and I regret to say that a good deal of the disease known as "Wilt" has appeared among the Java Khunties.

Extract from letter to Messrs. Begg, Dunlop & Co.

Dated August 4th, 1912.

We have had no rain to speak of for the last three weeks, and the prolonged drought has affected the Khunties adversely. It has not only stopped the growth of the Khunties, but the unfavourable conditions appear to have encouraged the spread of the disease reported in my last, and I regret to say that "Wilt" is now general. A good fall of rain might possibly check the disease, but I regret to say prospects of rain are very remote.

The season of 1911-12 was the worst season for wilt yet recorded at Belsund Concern. This is all the more remarkable because the climatic conditions were generally favourable to a good indigo season. In the first place the rainfall for the previous season had been abundant, a total fall of 52·23 inches having been recorded for 1911, of which 10·45 inches had been received in September, and 3 inches in October. The moisture for this season therefore must have been good to start with, and during March, April and May some good falls of rain were also recorded. The rainfall for July, August and September was below normal, but this as an ordinary rule is usually more beneficial than harmful, and there certainly cannot be any suggestion of waterlogging during this season. Owing to the attack of wilt at Belsund Head Factory during 1911, a rough record of the sunshine during July, August and September 1912 was kept, and it will be noted there were very few days in these months on which sunshine was not recorded. It is also interesting to note that despite the very favourable conditions already mentioned, the return per bigha for the first cuttings was very poor. This circumstance almost points to the fact that the wilt disease was already affecting the plant to some extent during first cuttings. This is borne out by the fact that the yield of finished indigo per 100 mds. of green plant was considerably lower during this season than in others. The details with reference to this season have been given as fully as possible, as, in connection with the disease known as wilt, the experiences of this season are particularly interesting. It is not possible within the limits of this article to give details from the Manufacturing Records, but it may be stated here that the poor vat produce was confined to the Java indigo sown in the usual manner. There is another description of sowings known as "Chittha" which is described later,

and the vat produce from these sowings was not affected. Now it has been always observed at Belsund that "Chittha" indigo never shows signs of wilt.

SEASON 1912-13.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st ...	May 26th to June 12th and June 27th to July 12th	1,204	91	35	3	1
2nd ...	Manufactured at Bhagwanpur Out-factory					

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st ..	May 25th to June 15th and June 24th to July 22nd.	918	124	7	5	6½
2nd ...	July 23rd to 28th and August 27th to 29th.	227*	10	24	1	14
			TOTAL	...	7	4½

* Inclusive of Belsund plant.

Rainfall 1913.

	Inches
May	5·52
June	23·34
July	16 26
August	15·82
September	8·60
TOTAL	69·54

The monsoon broke this year on May 29th and it rained continuously until July 1st, 29 inches rain being registered in the interval. All lands were under water, most of the first cuttings being taken in water.

The second cuttings which escaped the water showed no signs of wilt disease.

SEASON 1913-14.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo			Produce per bigha	
			Mds.	Srs.	Chtks.	Srs.	Chtks.
1st ...	July 9th to 30th	413	88	18	5	8	11
2nd ..	Sept. 5th to 11th ..	170	12	14	0	2	14
			TOTAL			11	9

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st ...	May 16th to July 21st ..	761	145	0	10	6
2nd ...	July 22nd to Aug. 3rd and Aug. 9th to Sept. 15th.	521	111	25	8	9
			TOTAL ..		18	15

Rainfall 1914.

	Inches
May	0·85
June	2·87
July	5·70
August	22·25
September	3·00
TOTAL	34·67

Owing to the bad returns of the two preceding seasons the cultivation of indigo had been greatly reduced in 1912. At Belsund Head Factory chiefly rice lands which are not suitable for second cuttings had been sown in indigo, and first cuttings were not started until July 9th, and the subsequent heavy rain in August swamped any lands suitable for second cuttings. Bhagwanpur Out-factory had a larger area of high lands and the return from second cuttings was good. There was no sign of wilt this season.

Season 1914-15.

Belsund Head Factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigha	
			Mds.	Srs.	Srs.	Chtks.
1st	May 21st to July 19th	1,635	253	14	6	3
2nd	July 20th to 23rd, August 5th to 12th and August 26th to 29th	369	41	18	4	8
			TOTAL		10	11

Bhagwanpur Out-factory.

Cuttings	Dates	Bighas	Finished Indigo		Produce per bigh	
			Mds.	Srs.	Srs.	Chtks.
1st	May 18th to June 12th and July 3rd to 21st	872	138	36	6	6
2nd	July 22nd to 31st, August 4th to 11th and August 24th to 27th	312	42	24	5	12
			TOTAL		12	2

Rainfall 1915.

July	Inches		Inches
3rd	... 3·23	May	. 1·59
4th	.. 2·50	June	.. 4·67
5th	. 0·85	July	... 15·98
6th	.. 0·50	August	.. 18·45
12th	.. 3·00	September	... 9·60
23rd	. 1·10		
24th	... 0·70	TOTAL	.. 50·29
25th	.. 1·70		
26th	... 1·20		
27th	... 0·70		
30th	... 0·50		
TOTAL	15·98		

The poor return from first cuttings this year is due to the fact that a large area of Sumatrana indigo is included in the amounts given. Second cuttings were destroyed by a heavy flood during the early part of August. Previous to the flood the second cuttings however had not grown well, and wilt was reported to a small extent at Bhagwanpur Out-factory.

The distribution of the rainfall during July was not favourable to these cuttings.

Early Prospects.

When Java indigo was first introduced into Bihar, it was confidently expected that a plant had been discovered which would go far to re-habilitate the industry in its struggle with the synthetic product. That these hopes were to some extent justified is proved by the Belsund returns for the first four seasons 1905 to 1908, especially if these returns be compared with those obtained from the Sumatrana indigo for the same seasons. The following is a comparison of these returns.

SEASON 1904-5.

Belsund Head Factory.

Java Indigo							Sumatrana Indigo					
Cuttings	Bighas	Indigo			Produce per bigha		Cuttings	Bighas	Indigo		Produce per bigha	
		Mds.	Srs.	Ch.	Srs.	Chtks.			Mds.	Srs.	Srs.	Chtks
1st	33½	8	21	8	10	3	1st	1,618	174	30	4	5
2nd	29	4	18	1	6	2½	2nd	562	16	0	1	2
	TOTAL	12	39	12	16	5½		TOTAL	190	30	5	7

SEASON 1905-6.

Belsund Head Factory.

Java Indigo							Sumatrana Indigo					
Cuttings	Bighas	Indigo			Produce per bigha		Cuttings	Bighas	Indigo		Produce per bigha	
		Mds.	Srs.	Ch.	Srs.	Chtks.			Mds.	Srs.	Srs.	Chtks.
1st	283	68	16		9	7½	1st	1,185	235	30	8	0

N.B.—Second Cuttings not recorded separately. Owing to floods return from these cuttings very poor.

SEASON 1906-7.

Belsund Head Factory.

Java Indigo							Sumatrana Indigo					
Cuttings	Bighas	Indigo			Produce per bigha		Cuttings	Bighas	Indigo		Produce per bigha	
		Mds.	Srs.	Ch.	Srs.	Chtks.			Mds.	Srs.	Srs.	Chtks.
1st	666	172	31	8	10	6	1st	712	73	10		
2nd	645	160	23	12	9	15	2nd	171	4	10		
3rd	303	21	14	4	2	13						
	TOTAL	354	29	8	23	2		TOTAL	77	20		

Season 1906-7.

Bhagwanpur Out-factory.

Java Indigo							Sumatrana Indigo					
Cuttings	Bighas	Indigo		Produce per bigha			Cuttings	Bighas	Indigo	Produce per bigha	
		Mds.	Srs.	Srs.	Chtks.				Mds.	Srs.	Chtks.
1st	133	42	18	12	12		1st ...	670	99	6	0
2nd	117½	44	16	15	2		2nd	230	24	4	2½
3rd ..	53	11	14	8	9						
	TOTAL	98	8	36	7			TOTAL	123	10	2½

Season 1907-8.

Java Indigo.

Belsund Head Factory						Bhagwanpur Out-factory						
Cuttings	Bighas	Indigo		Produce per bigha		Cuttings	Bighas	Indigo		Produce per bigha	
		Mds.	Srs.	Srs.	Chtks.			Mds.	Srs.	Srs.	Chtks.
1st	1,334	288	7	8	10	1st .	908	274	34	12	2
2nd	1,191	285	34	9	9½	2nd ..	614	148	24	9	11
3rd ..	233	30	26	5	4						
	TOTAL	604	27	23	7½		TOTAL	423	18	21	13

In 1905-6 the difference between the two indigoes was not so very marked, but as already recorded in another place, the poor yield from the Java indigo this year was due to inferior seed which did not germinate properly. In 1906-7, we find Belsund Factory making mds. 354 from a Java cultivation of bighas 666, while from a Sumatrana cultivation of bighas 712 it only made mds. 77½—a difference of about 500 per cent. In the same season Bhagwanpur Factory from a Java cultivation of bighas 133 makes mds. 98, against mds. 123 from a Sumatrana cultivation of bighas 670. In 1907-8, Belsund makes mds. 604 from a Java cultivation of bighas 1,334—a return of over 18 seers per bigha, Bhagwanpur Factory making mds. 423 from a cultivation of bighas 908—a return of over 18½ seers per bigha. There was no Sumatrana cultivation at Belsund Concern this season, so a comparison cannot be made, but the figures speak for themselves

especially when it is stated that a yield of 10 seers per bigha for Sumatrana is considered very good. If these results could have been maintained there would have been no doubt that the position of the industry would have been greatly improved. Unfortunately after 1908 a marked deterioration in the Java plant set in. There is nothing to show that this deterioration can be attributed to seed, as at Belsund Concern a fresh supply of seed was annually imported from Java, from which the indigo retained for seed purposes was sown. But this system was abandoned some years ago, as the plant from the imported seed showed no improvement on the more or less acclimatized plant. It cannot be urged that the seasons of 1908 and 1907 were specially suited for the Java plant as compared to seasons 1911 and 1912 when very poor yields were recorded. Of all the seasons here recorded, an experienced indigo planter would select 1912 as having the most favourable weather conditions.

Wilt.

As already recorded 1909 was the first year in which the disease known as wilt attacked the plant to such an extent as to affect the yield of finished indigo. There are however marked indications that this disease was present to some extent in the earlier years, and that it was affecting the yield of seed in those years. In 1905 the yield of seed from uncut plant was mds. 13 per bigha, in 1906 mds. 8 per bigha. In 1907 the yield of seed was poor from the uncut plant, the Khunties or 2nd Cut Plant giving a better yield. In 1908 only Khunties were retained for seed and the yield was fair. In 1909 the yield of seed from the Khunties was very poor, and in 1910 the system was introduced of sowing for seed in August. Plant sown in August can usually be depended on to give a yield of 2 to 3 maunds of seed per bigha during the succeeding months of February and March. It appears therefore that there is some evidence that in the years 1906-7 wilt, although it was not then recognized as a disease, was attacking the *uncut* seed plant to some extent.

It has always been the experience at Belsund that wilt never appears until the plant has reached maturity, and the stems become woody. It is probable therefore that in 1907 wilt

attacked the woody uncut plant, but the Khunties which were cut back in June escaped.

If a comparison be made of the Belsund Returns and Records of Rainfall, it is impossible to escape the conclusion that climatic conditions have little if anything to do with wilt. In 1905 and 1906, years of abnormally heavy rainfall, the yield of seed from the uncut plant was exceptionally good, and it is extraordinary that subsequent to these years, it was found that it was useless to keep uncut plant for seed, with the single exception of 1915 when a small experimental plot gave a return of about mds. 4 per bigha. It is obvious that wilt could not have been present in any great extent during 1905 and 1906. Yet in 1909 another year of heavy rainfall wilt was very prevalent. On the other hand seasons 1908 and 1912 were years of short rainfall. If the character of the rainfall for these seasons be compared, it will be seen that there is a great similarity. Both seasons had very little rain in May and June followed by 11 inches in July, the distribution of the July rainfall being very similar; 1908 receiving 10·72 inches from July 1st to 15th, 1912 receiving 9·8 inches from July 1st to 13th. Yet there were no signs of wilt during 1908, while 1912 was the worst season for that disease; the Belsund yield in 1908 being mds. 604-27-0 from a cultivation of bighas 1,334, as against a yield of mds. 220-7-0 from a cultivation of bighas 1,470 in 1912. And if all factors be taken into consideration, the climatic conditions in 1912 were considerably more favourable than in 1908 for a good indigo yield. In 1911 it is also impossible to connect climatic influences on the appearance of wilt at Belsund Factory, when it is shown that the disease did not appear in the Bhagwanpur Factory cultivation, the distance of eight miles only, with both factories working under the same conditions.

A method of sowing Java known in the vernacular as "Chittha" has been introduced at Belsund. The seed is scattered in the standing rice during October *before the fields get too dry*; the rice is subsequently cut in December and the indigo is left to grow without any cultivation whatever, as owing to the ground baking as hard as asphalt it is impossible to plough. Now the disease of wilt

has never been known to appear in this class of sowings. The reason may be that the cover crop of rice retards the growth, and although the indigo comes away very quickly after the rice is cut, yet it never develops much wood. At the same time if wilt is due to starvation of nitrogen following on waterlogging or unfavourable climatic conditions, this class of sowings should be unduly liable to the disease; as the lands are particularly liable to waterlogging, and also the indigo never gets the benefit of any soil aeration by ploughing.

That the disease can appear in all classes of soil has also been the experience at Belsund. At the time of writing a field can be pointed out where the disease has appeared to some extent. This field is of a light sandy soil about fifty yards broad, bounded on one side by a river, on the other by a deep ditch, the natural drainage being perfect. A few hundred yards distance there is another low-lying field which has been in a waterlogged condition for the last twenty days, yet this field does not show the same amount of wilt as the first field. At the same time it should be noted that these conditions can be reversed.

General Remarks on Cultivation.

As already stated the conditions at Belsund are different from other localities, and the recommendations as to the methods suitable for cultivation there may not apply to other places, so these remarks are only offered for what they are worth. After ten years of different systems, it has been discovered that if the best return from the plant is to be obtained, and the ravages of wilt avoided, the earlier the first cuttings are taken the better, as after the break of the rains, the plant matures quickly and develops wood. For this purpose therefore the best system is :—

(1) To keep the lands for sowings fallow during the monsoon.
(2) Sow from September 25th to October 15th.
(3) Do not sow a cover crop, but keep the indigo well ploughed during cold weather.

Lands, however, of good quality should not be sown until after October 10th as, if sown earlier, they are liable to become overmature

before it is possible to cut them for manufacture. Poor lands should be sown as early as possible. Under this system, if moisture is good, the plant is ready to cut before the end of April, and gives a second cutting by July 15th. Returns of over 25 seers per bigha by July 15th have already been obtained in 1916 under this system at Belsund.

The plant should be cut flush with the ground, as in the hot dry month of May it sprouts best from under the ground. Grasshoppers unfortunately do a considerable amount of damage, but very few plants die, and on the first heavy shower of an inch or so they come away very quickly.

It has also been the experience at Belsund that the plant sown under this system gives a fair yield of seed in April, over mds. 500 having been obtained at Belsund in 1916 from plant sown in this manner.

With reference, however, to the above system of cultivation it must be stated that much depends on the price to be realized for the finished product, as with pre-war prices it is doubtful whether it would be profitable to abandon the cover-crop, in which case sowings would have to be conducted later. Fallowing, however, in the writer's estimation will always be profitable.

Seed Rate.

This varies according to the amount of seed available and the area of land to be sown, five seers per bigha being the usual average. That this quantity is not sufficient is very evident however from the condition of the crop, and the writer is confident that if the rate could be increased to eight seers, the result would be a large increase in the yield per bigha of finished indigo.

Manufacture.

With reference to the methods used in manufacture, these are in accordance with the recommendations made by Rawson and Bergtheil in their various reports. In respect to the indican content of the plant there appears to be no deterioration; in fact it appears to have improved since the plant was first introduced at Belsund.

Research Work.

Before closing this article the writer would like to make some remarks as to the lines on which research work would appear to give the best results. The first and most important point is a supply of seed. If a full supply of seed was obtainable, and the sowing rate increased, the result on the return of finished indigo would be very marked. The writer however is not at all confident that it will ever be possible to grow Java for seed with the best results in Bihar. In the first place the country is subject to periodical flooding at the time when the seed plant must be in the ground. In the second it is very doubtful whether any remedy will be found for the diseases such as "Wilt" and "Psylla." The system of sowing in August for seed has been practised at Belsund since 1910, the average yield being two to three maunds per bigha. The method of sowing the plant in lines was tried in 1915, but there was no marked increase in the yield. Drainage was also tried for the seed plant in 1915 with the result that the drained plot was an absolute failure owing to a bad attack of "Psylla," the undrained plot surviving and giving a fair return. It is probable that if a regular and full supply of Java seed is to be secured some other locality will have to be discovered for seed growing.

The next most important matter of research appears to be in the line of increasing the wilt-resisting power of the plant by selection; and after that is obtained, research should be directed to improving the indican content of the leaf. A certain amount of success on these lines would probably obtain results that would put the indigo industry on a very sound footing.

ADDENDUM.

With reference to wilt a note on the experiences of the present season is of interest. The monsoon broke at Belsund on June 20th, 1916; up to that date less than 4 inches had been recorded, and no single fall of an inch or over had been received since October 19th, 1915. Between June 20th and July 1st about 9 inches of rain were recorded, the chief falls being about 5 inches

on June 20th and 21st and 2 inches on July 1st. Early in July wilt began to make its appearance. From July 8th to August 20th about 25 inches rain were recorded, rain was recorded on 23 different days, and the lands throughout this period were never dry, the lower lands being constantly under water. Yet on August 20th wilt had not increased to any appreciable extent, in fact it had to some extent disappeared. The plant of course had not grown but the second and third cuttings though very small were green and healthy. In low lands where water had lodged for a long period, the plant had the appearance of waterlogging, the lower leaves turning yellow and dropping but the upper leaves were green. This is entirely different from the appearance of wilted plant. In wilt the leaves of the entire plant or one particular shoot are affected more or less simultaneously.

Further an exceptional early flood in the Bagmuttee river flooded some second cuttings which had been first cut in early May. This flood occurred about July 4th and subsided in a few days. After it had subsided as already stated, there was continuous rain up to August 20th. Yet any plant which had not been entirely submerged survived and showed no signs of wilt and gave a good cutting about August 20th.

My practical experience with Java Indigo does not, I am afraid, agree with certain recommendations which have gained considerable publicity as to the growing of the crop. My experience is that Indigo is not killed outright by standing water, and that wilt is not affected to any great extent by climatic influences; at least that is the only inference I can draw from my statistics and from actual results with the crop. [D. J. R.]

LEGUMINOUS CROPS IN DESERT AGRICULTURE.[1]

BY

ALBERT HOWARD, C.I.E., M.A.,

Imperial Economic Botanist,

AND

GABRIELLE L. C. HOWARD, M.A.,

Second Imperial Economic Botanist.

I. INTRODUCTION.

THE development of Indian Agriculture is largely a problem of increasing the production of the soil. Only in this way can the country continue to support its growing population and provide the surplus wealth on which alone future schemes of development can be based. This increase in production includes the conquest of the desert by means of irrigation, a process now in rapid development in North-West India. Irrigation by itself, however, is not sufficient permanently to reclaim the desert tracts. After a time, the fundamental defect in these soils—lack of organic matter—begins to tell and the produce soon falls off both in amount and also in quality.[2] The obvious method of increasing and maintaining the supply of organic matter is by means of green manure. This is, however, a counsel of perfection as in such areas the cultivator is not likely to expend the water and labour necessary to grow green manure and also to bring about its decay in such a manner

[1] Received for publication on 2nd October 1916.

[2] It is true that, at the beginning, surface-flooding produces large crops and that the amount of water required for the purpose is relatively small. This is largely due to the good natural aeration of desert soils. Surface flooding, however, soon destroys this, the sub-soil becomes more compacted, root-development is restricted and more and more water is required to ripen the crop. Alkali salts also begin to appear and the general fertility diminishes.

that the next crop derives the maximum advantage from this form of soil enrichment.

The problem is to discover a method by which the organic content of these desert soils can be increased which will, at the same time, prove profitable to the cultivator. The solution is to be found in the extended growth of leguminous fodder-crops like *shaftal* (*Trifolium resupinatum*), lucerne, berseem (*T. alexandrinum*), *senji* (*Melilotus indica* and *M. alba*), and *guár* (*Cyamopsis psoralioides*, DC.), which are now largely grown for green fodder round the towns of North-West India. In the Districts themselves, however, the area under these fodder-crops falls off as there is little sale for the produce in the green state and no proper methods of drying and storage exist. What the country now needs is a method of drying and baling these fodders and also a market for the dried produce. Once this is provided, the cultivation of these fodder-crops will develop rapidly and the *ryot* will then be provided automatically with a profitable means of increasing and maintaining the organic matter in the soil. Although these fodder-crops will be reaped, they leave behind a large amount of organic residue in the soil in the shape of roots and nodules and, as is well known, their cultivation involves the fixation of large quantities of atmospheric nitrogen.

The extended growth of leguminous fodder-crops solves another problem besides that of the supply of organic matter to the soil. Indian agriculture, as is well known, rests on the efficiency of the ox which is exceedingly low on account of a chronic shortage of nutritious food. The cattle engaged on the land and in transport on the roads are largely fed with substances of low feeding value like *bhusa*, *juar* and maize stalks and with the miscellaneous chaff of the threshing floors. The amount of grain given to work cattle is small as this substance is needed by the cultivator for food and as a source of income. The weak point in the cattle ration of India is the disproportion of albuminoids to carbohydrates or, as it is expressed in works on foods and feeding, the low albuminoid ratio. Efficient and rapid work is not possible for any length of time in the case of any animal if the albuminoid ratio falls much below 1 : 7. As it is quite the exception to find an Indian ox provided with

fodder with a ratio approaching this minimum limit, it is easy to understand that the slowness and low efficiency of this animal is, to a large extent, a natural result of poor feeding.

To obtain better and faster work, the albuminoids in the food must be increased. It is of little use altering the breed as no working animal has yet been discovered which can do the maximum work on a food of the nature of wheat *bhusa*, the albuminoid ratio of which is not more than one to thirteen. This defect in the feeding of animals in North-West India can to a considerable extent be made up without the use of grain by means of properly dried and stored leguminous fodder-crops—*shaftal*, lucerne, berseem or *senji*. Analyses of these dried fodders disclose an exceedingly high albuminoid ratio[1] ranging from 1 : 3 to 1 : 4. Actual feeding trials in the Army at Quetta prove that working animals like horses and mules thrive on comparatively small quantities of such fodder. A mixture of from one to two parts of *bhusa* to one part of baled *shaftal* or lucerne provides a well balanced ration to which the addition of grain is unnecessary except perhaps for heavy work.

During the last few years, a considerable amount of attention has been paid at Quetta both to the enrichment of the desert soil with organic matter by the growth of leguminous crops and also to the best methods of drying and baling the produce. Although this work is still in progress, results have been obtained which clearly indicate one of the chief directions in which the arid regions of the North-West can be made to yield their maximum produce. At the same time, the way has been opened for the development of improved animal production in these tracts and for the building up of a new and profitable industry in the form of the supply of baled leguminous fodders for Army purposes and for the cattle employed in ordinary transport and in the cultivation of the land. The present paper deals with the progress made in these matters up to the end of the year 1916.

[1] The albuminoid ratio is best expressed as the ratio of *digestible* albuminoids to *digestible* carbohydrates. As the digestion data of Indian fodders when consumed by Indian animals have not yet been determined, it is not possible to adopt the more accurate method. In this paper, therefore, albuminoid ratios have been calculated from the analyses.

II. The Drying and Baling of Leguminous Fodders.

The two most suitable leguminous fodders for growth in the upland frontier valleys appear to be Persian clover or *shaftal*[1] and lucerne. The former is an annual which should be sown at the beginning of September and which gives as many as six cuts before dying down after flowering in June. Lucerne is of course a perennial which, however, ceases to be profitable in the Quetta valley after five or six years.

Under Baluchistan conditions, both *shaftal* and lucerne do best on manured land, a result presumably connected with difficulties of soil-aeration after the surface is flooded. Where water is scarce and manure can be obtained, intensive cultivation gives the best results and markedly increases the value of the water. Manuring, however, is only possible in the immediate neighbourhood of towns and villages so that this method of increasing the ventilation of the soil is not generally applicable. Under such conditions, *shaftal* does much better than lucerne as a fresh crop on poor land. The succeeding clover crops, which can be taken on the same land several years in succession, rapidly improve and, after two or three years, the land is in a fit condition for growing lucerne.

The annual yield of green *shaftal* on land in fairly good condition near Quetta is very great. A trial in 1915-16 at the Fruit Experiment Station showed that the total produce of the six cuts was over 33 tons to the acre, the value of which, at eight annas per hundred pounds, came to Rs. 371 an acre.

Drying.

In order to produce hay of the best quality, attention must be paid to the stage at which these fodders are cut. It is a general rule with clovers that the leaves are exceedingly rich in nitrogen and that the albuminoids they contain are more digestible than those in the stalks. Ritthausen[2] calculated that the leaves of red clover contained 22·3 per cent crude albuminoids in the dry

[1] The cultivation of *shaftal* is dealt with in detail in Quetta Bulletin no. 5 (reprinted in the *Agricultural Journal of India*, vol. XI, no. 1, 1916).

[2] Wolff, *Farm Foods*, 1895, p. 160.

substance and the stalks only 12·0 per cent so that the leaves alone represent more than half the albuminoids in the whole plant. When flowering begins, the percentage of albuminoids rapidly falls while the amount of crude fibre increases.

The facts with regard to lucerne are very similar. Lucerne is, however, more nitrogenous than many of the clovers but woody fibre is developed very rapidly after the beginning of the flowering period. To obtain the most nutritious fodder and also the maximum yield, it is clear that in both cases (*shaftal* and lucerne) the crop should be cut as often as possible and that the greatest care should be taken in the drying process to avoid damage to the leaves.

Besides the difficulty of preserving the leaves during the drying process in an arid climate like that of Baluchistan, the retention of sufficient moisture in the dried product itself to admit of stacking and baling must be provided for. Unless care is taken, the fodder dries out entirely, the leaves are lost and only the innutritious stems remain. The loss which takes place through over-drying will be evident from the analyses of Quetta lucerne prepared without destroying the leaves and dried in the country fashion in the form of lucerne ropes.

TABLE I.

Analyses of Quetta lucerne.[1]

	Baled lucerne (leaves intact)	Lucerne ropes (leaves partially destroyed)
Moisture ..	3·14	5·00
Ether extract (fats) ..	3·32	2·90
Albuminoids .	15·48	11·71
Soluble carbohydrates ...	46·30	43·87
Woody fibre ..	17·70	27·95
Soluble mineral matter ...	11·83	8·10
Sand ...	2 23	0·47
Total ...	100·00	100·00
Albuminoid nitrogen ...	2·48	1·87
Total nitrogen ...	2·98	2·19
Albuminoid ratio ...	1 : 3·5	1 : 4·3

[1] The analyses of dried lucerne and *shaftal* referred to in this paper were carried out by Mr. J. Sen, Officiating Imperial Agricultural Chemist at Pusa.

The most interesting points in these analyses are the lower albuminoid content of the rope lucerne (due to the loss of leaves) and the high proportion of woody fibre compared with the baled produce. This excess of woody fibre over that in the baled lucerne is only to be expected as most of the lucerne grown near Quetta is cut too ripe, usually after flowering has commenced. On the basis of the unit system (albuminoids = 2·5, fats = 2·5, and soluble carbohydrates = 1) and taking the lucerne ropes at Rs. 3 per maund, the value of the baled product would be Rs. 3-8-0 per maund or an increase in value of nearly 17 per cent due to the method of drying alone. This, however, does not represent the full superiority of the baled lucerne as the method of calculation does not take into account the superior digestibility and palatability of this product.

The preservation of the leaves during drying both in the case of *shaftal* and lucerne is accomplished by conducting the operation in stages. *Shaftal* dries much more slowly than lucerne so that the beginner should not attempt the drying of lucerne till he has mastered the details in the case of Persian clover. After cutting, the *shaftal* is spread out to dry for a day or two when it is turned and allowed to dry for another day. It is then collected into heaps and pressed down somewhat firmly to check the rate of drying. Provided the clover is put into heaps just at the right stage, a slight fermentation begins and on the second day the fodder begins to get slightly warm. At this point, the heaps should be opened and the fodder spread out for a short time in the sun to get rid of the excess moisture. Care should be taken not to over-dry at this stage as the only way of dealing with over-dried clover or lucerne at Quetta is to spread it out for the night on land recently irrigated when it takes up the right amount of moisture to allow of handling without damage. This, however, involves a great waste of time and labour and should be avoided when possible. After remaining a few days longer in heaps, the fodder can either be stacked or else baled at once. Some judgment is required as to the exact stage at which baling can be carried out. If the *shaftal* is too damp, too much fermentation takes place in the bale and the pale-green colour is

lost. If, on the other hand, it is too dry, no fermentation at all occurs and the leaves are broken a good deal during the pressing. It is safest to bale with the minimum amount of moisture which prevents any breakage of the leaves. Such matters, however, can only be learnt by experience.

Lucerne is much more difficult to dry than *shaftal* as it loses moisture more quickly in all the stages of the process of hay-making. It is best to get the product collected into heaps on the morning of the third day and to complete the drying by opening the heaps once or twice afterwards. Once the product is dry enough it should be baled immediately as at Quetta it dries very rapidly in the stack and soon becomes too brittle to handle.

Baling.

The preparation of baled leguminous fodders is a matter which involves the expenditure of some capital and is therefore beyond the means of the ordinary cultivator. The process can most advantageously be carried out at centres where ample supplies of green fodder can be produced and where there is no great competition for the available supplies such as always exists in large towns and military cantonments. The needs of the urban population for green fodder in North-West India are already considerable and the demand which now exists does not leave any great surplus for drying and baling. To obtain the maximum advantage to the land and to give the dryer and baler a fair profit, it would appear that the balance of advantage is to be obtained by the formation of drying and baling centres at some little distance from the large centres of population. In a tract like the Quetta valley for example, a considerable area of the country-side, within a six mile radius of the Cantonments, is taken up with the growth of green fodder for the Army and the town. To set up a drying and baling station for profit at Quetta itself would merely add another competitor for the existing produce and might easily raise the price. A few miles out of the town, however, the conditions are quite different and here the establishment of baling stations would be sure to lead to the extension of *shaftal* and lucerne cultivation for drying purposes

only. The preparation of the bales would appear to be best done either by the large zamindars or by contractors who could purchase the green fodder from the cultivators and dry and bale it themselves.

The type of bale to be produced is of some importance particularly when the fodder has to be sold to the Army. For transport purposes by mules, the bales should weigh as near a maund as possible so that two bales can be loaded on one animal. They should also be pressed as tightly as possible. A baling machine driven by an oil engine would no doubt produce the best bales for Army purposes and such installations may prove profitable in years to come when the use of dried leguminous fodders becomes universal. At first, however, the pressing can be done by portable hand presses which are comparatively cheap and which are now made in India itself. The drying ground could be rented for a small sum annually and the spare time of the workmen necessary for making the hay could be used up in baling. As fast as these are made they could be transported, at contract rates, to the towns and sold at once. A cheap temporary shed, or better a few tarpaulins are all that is necessary to protect from rain the hay awaiting baling and the bales ready for transport. In tracts like Baluchistan, the baling of *shaftal* and lucerne would extend from the middle of March to the end of October. These two fodders supplement each other very well. The *shaftal* crop extends from the middle of March to early June, while lucerne comes in in May and lasts till October. Such work could be done by Indians and the development of the trade in dried leguminous fodders offers a profitable opening for the rising generation.

III. THE FEEDING VALUE OF SHAFTAL AND LUCERNE HAY.

Once the difficulties of hay-making in the North-West are overcome, the resulting fodder stands in a class by itself as far as India is concerned. The *shaftal* and lucerne hay prepared at the Fruit Experiment Station, Quetta, are equal to the very best grades of these fodders made in Europe. The composition o

these two foods was determined at Pusa with the following results :—

TABLE II.

Composition of shaftal and lucerne hay at Quetta.

	Shaftal (in bales)	Lucerne (in bales)
Moisture ..	15·86	3·14
Oil .	2·19	3·32
Albuminoids ..	14·10	15·48
Soluble carbohydrates ..	39·98	46·30
Woody fibre ..	13·80	17·70
Soluble mineral matter ...	12·88	11·83
Sand ...	1·19	2·23
Total ...	100·00	100·00
Total nitrogen	2·48	2·98
Albuminoid nitrogen .	2·26	2·48
Albuminoid ratio	1 : 3·2	1 : 3·5

Rations.

The analyses of these two fodders at once disclose the fact that they are too concentrated for use by themselves. Such a ration, in which the proportion of albuminoids to carbohydrates is as high as 1 : 3·2 would involve a great waste of proteids. Horses for the very hardest work do not require an albuminoid ratio of more than 1 : 5·5 while for draught oxen 1 : 7·5 is sufficient. Taking horses and mules together, a fodder consisting of *bhusa* and *shaftal* hay in equal parts would possess a ratio of 1 : 5. In this calculation, *bhusa* is taken to contain in every hundred parts—fats 0·98, albuminoids 3·01, and soluble carbohydrates 37·93. This ration would be suited for transport purposes under service conditions and little extra grain would be required. Fifteen pounds of such a ration would be ample for a mule weighing 800 lb. and it might even be possible to reduce it to 14 lb. For ordinary light work, the proportion of *bhusa* to *shaftal* hay could be increased. A

ration consisting of two parts of *bhusa* to one part of *shaftal* hay would give a food with an albuminoid ratio of 1 : 6·2 which would keep horses, mules and cattle in ordinary work in good condition without the addition of grain.

Besides their feeding value, the above rations possess two other great advantages. In the first place, the substitution of *shaftal* or lucerne hay for grain as the main albuminoid carrier combined with the reduction of the amount of *bhusa* would lead to a great saving in weight, a matter of obvious military advantage in all kinds of Army transport work. In the second place, the partial elimination of grain from the ration would reduce pilfering as hay cannot be consumed by human beings. That the reduction in weight will be considerable will be evident when it is remembered that the mules in the Mountain Batteries now at Quetta obtain the following daily rations :—

Bhusa	15 lb.
Grain	6 lb.
Green lucerne	5 lb.
Total	26 lb.

The green lucerne would probably be given up on active service but for each mule, weighing about 800 lb., at least 20 lb. of dry fodder per day would have to be provided, part of which would be grain. Fifteen pounds of the ration :—

Bhusa	7½ lb.
Shaftal hay	7½ lb.

would probably be better than 20 lb. of *bhusa* and grain and thus a saving of 25 per cent in weight might be made. These numbers are given merely as a guide for future trials. The final ration adopted will naturally depend on the result of extended trials.

Trials of shaftal hay.

Up to the present, two sets of trials with *shaftal* hay have been carried out by the Army at Quetta. The first took place in 1915 on the horses of the 72nd Heavy Battery, R.G.A., and was arranged by Major Hislop. The Commandant, Colonel M. H. Courtenay, R.A.,

reported on the trials as follows (Letter dated, Amara, July 30, 1915) :—

"Up till I left my battery (72nd Heavy Battery, R.G.A.) I used *shaftal*. I found 3 lb. *bhusa* to one of *shaftal* made an excellent chop, and the horses throve really well on it and the *shaftal* made even the shyest feeders eat *bhusa* freely. I prefer dried *shaftal* to dried lucerne and further I saved at least 25 per cent in cost. I can strongly recommend it to any horse-owner in Quetta."

The second test was made in 1916 on one of the mule teams of the 4th Mountain Battery at Quetta, the arrangements for the trial being made by Brigadier-General Cook, R.G.A., the General Officer Commanding the Artillery of the Fourth and Fifth Divisions. Major Hassels-Yates submitted the following report on the trial :—

Test carried out by the Officer Commanding No. 4 Mountain Battery, R.G.A., of the food value of *shaftal* :—

"*Test.* The mules selected to undergo the test were six mules forming a gun-line ; *i.e.*, strong mules doing the hardest work required of Mountain Artillery mules. They were of various breeds—two North American, two country-bred and two Chinese. They were all in perfect condition, and of the best working age ; *i.e.*, from 8 years old to 11 years old.

During the test, the mules did their ordinary work but were kept stabled in separate loose-boxes so that their feeding could be controlled and each mule be specially watched. They were weighed before the commencement of the test and again after every 7 days. The weighing machine used was the weigh-bridge at the goods-yard of the Railway Station. Unfortunately this machine was never in correct adjustment and varied each week ; consequently no accurate results have been obtained from the weighings.

Before the test, the daily food of these mules consisted of 6 lb. of grain (gram, barley and bran), about 10 to 15 lb. of *bhusa* and

about 5 to 8 lb. of green lucerne. All this was discontinued at the commencement of the trial and the mules were given daily 14 lb. of dry *shaftal* hay. After certain changes, it was found best to give this amount in the following proportions:—at 6 A.M. 2 lb., at 12 noon 4 lb., at 6-30 P.M. 8 lb. The test lasted 21 days.

Observations during test. Shaftal is a dry fodder and practically non-absorbent. Consequently the animals required to drink frequently while feeding. In the absence of water they ate little, especially during the heat of the day. Water was kept in the stalls in open tubs and each mule drank about 15 to 20 gallons in the 24 hours, which may be considered to be much above ordinary requirements.

Towards the end of the test especially the mules ate the *shaftal* with relish.

Twelve to 13 lb. appears to be the necessary daily allowance for these gun-mules; and therefore, presumably, the allowance for a smaller mule (such as a transport mule) should be about 10 lb.

After a few days of the test, the dung became very dark and remained so till the end; but there was never any sign of constipation. The urine became thick and darkened, frequently becoming red.

This condition of the urine existed to a certain extent throughout the test, was worst during the second week of the test, and got better during the third week. One may from this draw the conclusion that it took about a fortnight for the kidneys, etc., to get the power to throw off the large quantities of salts existing in all types of clover. No medicinal salts were given to rectify this condition. Probably the great amount of water drunk by the mules was necessary on this account, and was the means by which the kidneys, etc., were kept flushed and cleaned. Beyond this there was never any sign or symptom of any abnormal physical condition.

At about the tenth day of the test it was noticeable that the mules had lost condition; but later on they gradually regained it, until towards the end of the three weeks they looked in perfect condition.

The mules became much finer in appearance than the remainder of the Battery mules ; coats glossy, less fat, and in every way in perfect condition. They sweated less than other mules when doing hard work ; but, especially during the middle week, laboured slightly and breathed more heavily at work. The only conclusions admissible from the weighings are :—

(1) The mules lost some weight up to the 10th or 14th day.

(2) After that time, they remained at this weight, neither gaining nor losing.

Conclusions. 1. Fourteen pounds of *shaftal* in the case of a Battery mule, and 10 lb. in the case of a smaller type of mule is sufficient food for one day.

2. On this amount a mule ought to be able to do its normal work.

3. It is absolutely necessary that a mule must have water in plenty available always.

4. It might possibly be necessary to give salts in some cases to rectify the condition of the kidneys and urinary organs reached after about a week of this feeding.

5. Animals fed in this way are at their worst condition during the second week but after that period regain condition and suffer no further.

Further notes. The test was concluded on the 21st day. By this time the mules, as stated above, were in perfect condition and by now thoroughly accustomed to the feeding and able to derive the full benefit from it. On this day ordinary feeding was partly resorted to. A very small quantity of grain mixed with bran, some *bhusa*, and lucerne was substituted for half the *shaftal.*

It was presumed that, accustomed now to the *shaftal,* the mules would prefer it ; and also that the change would have to be carried out very gradually.

As absolutely no abnormal physical conditions were apparent, or any sign of colic, indigestion, etc., and as the mules infinitely prefer the grain and *bhusa* feed, the change has been carried out rapidly with no harmful effect.

I see no reason why an animal should not be brought back directly from entirely *shaftal* feeding on to the usual Government ration."

The following observations were recorded by Brigadier-General Cook, R.G.A., who followed the trials from the commencement :—

" With the consent of the General Officer Commanding the Division, an experiment as to the feeding value of *shaftal* or Persian clover hay was carried out from 19th June to 10th July by the Officer Commanding No. 4 Mountain Battery, R.G.A., at Quetta, following a suggestion by Mr. Howard, the Imperial Economic Botanist.

The report of the Officer Commanding No. 4 Mountain Battery and various papers forwarded by Mr. Howard are attached.

The salient points of the experiment are :—

(1) The mules were at once placed on a total ration of 14 lb. of *shaftal* in lieu of the previous ration of 6 lb. corn, 10 to 15 lb. *bhusa*, and from 5 to 8 lb. green lucerne without previous preparation.

(2) The mules at the end of the experiment were in first class condition, and in my judgment in better condition than before.

(3) Except for a reddening of the urine and some slight loss of weight during the second week, no ill-effects were experienced.

(4) The animals readily took to the new fodder and as readily returned to their previous rations.

(5) The mules weighed from 890 to 1,050 lb. each before the trial, thus approximating to the weight of a light horse.

The object of the experiment was to determine how far *shaftal* hay could replace the grain and fodder ration issued to an animal on field service. The normal ration for a Battery mule is 9 lb. corn and 10 lb. forage (hay or *bhusa*) on service. The experiment goes to prove that 14 lb. of *shaftal* is sufficient to keep a gun-mule in first class condition.

Thus there would be a saving in weight of rations supplied in the field of 5 lb. per animal.

It is Mr. Howard's contention that by the use of *shaftal* hay there would be a saving in transport of at least 30 per cent wherever grain and fodder have to be carried, thus reducing the transport. Apart from this the military aspect of the case, Mr. Howard expects considerable advantages to accrue to the Government and civil population if the cultivation and preparation of *shaftal* hay were encouraged on a larger scale. Please see pages 4, 5, 6 and 7 of Mr. Howard's report on 'The Development of the Agriculture of Baluchistan.' It is not contended that *shaftal* hay would entirely replace the grain ration for animals doing fast work ; but further experiments in this connection might be attempted.

I would, therefore, submit that the results of this experiment be forwarded to Army Headquarters for consideration as to whether experiments on a large scale should be undertaken."

It will be observed that the trials with *shaftal* hay by itself were quite successful, and that mules can do hard work on this forage without deterioration. Such a food, however, is too concentrated for general use, and a marked reduction in cost could be obtained by feeding equal parts of *shaftal* and *bhusa* as suggested above.

The results of these trials have been brought to the notice of the General Officer Commanding the 4th Division and the Army Headquarters at Simla. The result has been that General Sir Malcolm Grover has given orders for extended trials of *shaftal* hay during 1917. Six thousand maunds of this fodder will be purchased by the Army next year for further tests. Steps have been taken to have this amount grown by the zamindars near Quetta and it is proposed to start three baling stations for this purpose—at Quetta, Sheikh Mandah, and Karak.

IV. Leguminous Fodders in India.

It will be clear from the foregoing that a reliable market is the first condition of success in the spread of leguminous fodders in North-West India. The cultivator must have same means of disposing of his produce at reasonable rates when he will be quick to see the advantage to his land of growing larger areas of crops like *shaftal*,

lucerne, berseem and *senji*. At present, the best customer in the fodder market is the Army who annually purchase large quantities of grain, *bhusa* and green crops for current use and for the maintenance of a fodder reserve. If the Army decides, after the Quetta trials are completed, to purchase these baled leguminous fodders in bulk and to adopt them as part of the ordinary ration and for reserve purposes, future success is assured. A great opportunity for developing the country will then present itself in which the Army authorities and the Government can work together to the mutual advantage of both. In such a matter, the Army will not function as a mere spending department but as a powerful agent of development in that region of India in which it is mainly concentrated.

Once the Army comes into the market for these dried fodders, their extended use is certain. Anyone who has seen the poor feeding of the thousands of cattle engaged in moving produce over the main trunk roads in the North-West will at once realize how much these fodders would improve the efficiency and reduce the numbers necessary for the work. In urban areas, both cattle and horses are underfed and overworked. The numerous dairies springing up in the large towns are producing milk, inferior both in quality and quantity, to that which would be possible if the albuminoid ratio of the fodder could be improved. For famine reserves, these baled fodders would be of the greatest use. Such produce is easily stored for long periods, is readily transported and the quantity is easily checked by merely counting the bales. It is highly nutritious and therefore would be a useful reinforcement to such materials as *bhusa* and dried grass whose function would be the dilution of the leguminous hay.

Once these fodders become general in North-West India, the producing power of the soil is bound to increase. The work cattle will be better fed and the door will be opened for a more intensive cultivation of the land and for the use of heavier and better implements. The country will, at the same time, support a larger population and with the increased production of the soil the prosperity of the people will rapidly improve. Indian agriculture is at present

labouring in a vicious circle. The land does not produce enough to admit of the work cattle being properly fed. Without more efficient oxen it is difficult to adopt the simplest cultural improvements. Only the surface of the soil is scratched and only the merest skin of the deep alluvial soils of the plains is made use of by crops. This vicious circle, however, can be broken. Nature in the form of the nitrogen-fixing leguminous fodder crops provides the means. The resources of the State, properly directed, are amply sufficient to utilize this means.

THE DOMESTICATION OF THE INDIAN HONEY-BEE.*

BY

REV. L. V. NEWTON, S. J.,

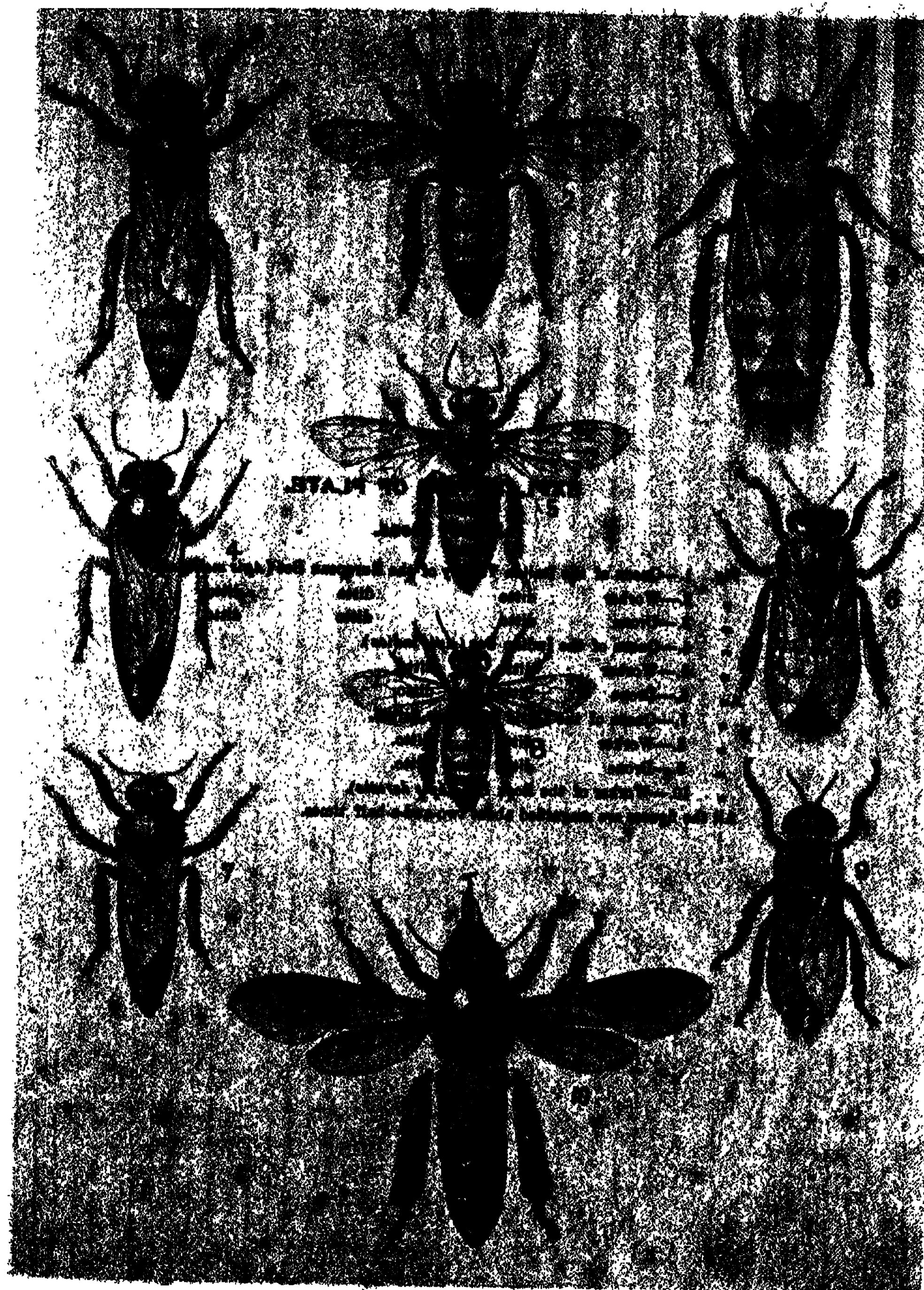
of St. Joseph's College, Trichinopoly.

A SHORT time ago I came across a copy of a report by Mr. T. Bainbrigge Fletcher on " Bees and the Fertilization of Coffee," I was much interested in it, and while reading the idea struck me that it might be of some use and interest to other bee-keepers if I were to jot down my observations and conclusions during the many years I have busied myself with Indian bees.

The Indian Honey-bee (*Apis indica*) has been cultivated and observed in the gardens attached to St. Joseph's College, Trichinopoly, for a period (with some slight interruptions owing to changes in the College staff) of over a quarter of a century. The Rev. J. Castets, S. J., began to make a study of the various Indian bees about 1890, and in 1893 published the results of his observations in the " Revue Scientifique de Bruxelles " in an article which was afterwards reprinted separately. At that time he tried successively to domesticate the Rock Bee (*Apis dorsata*), the Little Bee (*A. florea*) and the Indian Bee (*A. indica*), but soon came to the conclusion that the last alone could be kept profitably in a hive. In these experiments he was greatly helped by the Rev. Fr. Bertram, S. J., the present Rector and Principal of the College ; I myself was mostly an interested onlooker lending an occasional hand. The Rev. Father Bertram had an opportunity later on to continue his observations at Shembaganur, near Kodaikanal, on the Palni

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* Received for publication on 3rd September, 1916.



HONEY BEES.

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BY

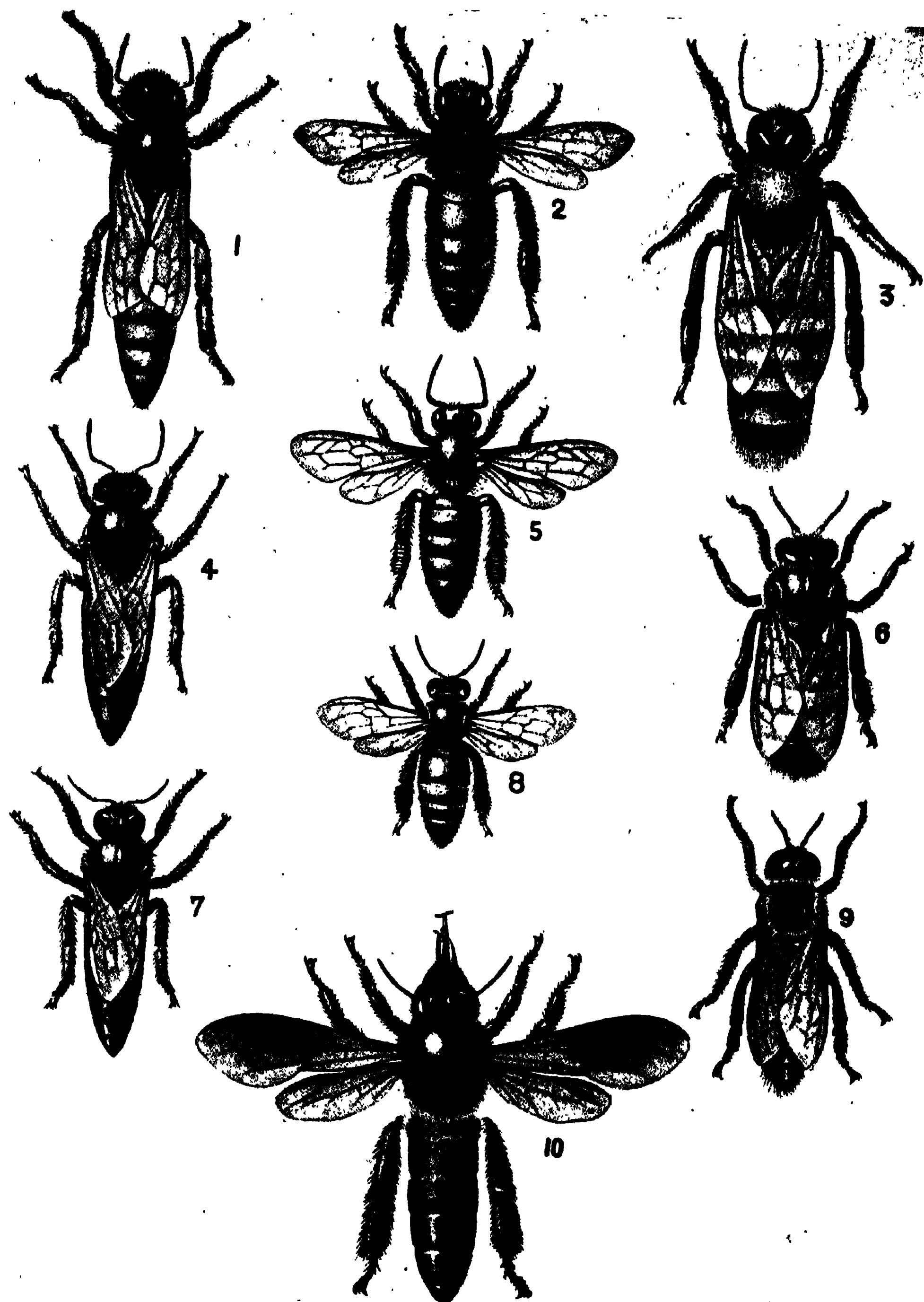
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HONEY BEES.

Hills, and even tried to introduce Italian bees ; but his first experiment in this direction was brought to a sudden termination by thieves one night stealing, merely for a little honey, the comb containing the Italian queen, and that under circumstances when it was impossible to rear another. His resources would not allow him to go to the expense of importing a second Italian hive. Meanwhile I had continued to busy myself with the bees in the garden of the College at Trichinopoly, and in 1909, helped by advice from Rev. Father Bertram, I constructed a small honey-extractor of the simplest kind, which I have used ever since.

These preliminary observations may perhaps appear superfluous and somewhat egotistical. They have been introduced, however, with the idea of showing that the following notes are not merely superficial impressions obtained by a few weeks' casual acquaintance with bees and hives, but are the result of long experience and careful study of the Indian bee, and of trials carried out at different times by different observers.

The bee with which I have experimented is the yellow variety of *A. indica* found in the Plains of Southern India. It differs from the dark Hill variety not only in colour, but also in size, being appreciably smaller. This fact should be kept in mind when determining the size of one's hives and frames. Before proceeding to describe the methods I have followed and the forms of hives and other appliances I have used, it may be advisable first to say something of the economic value of the Indian bee, and of the amount of honey it can be made to yield. We shall then be able to give some sort of answer to the question whether it is worth while encouraging the domestication of the *A. indica* or not.

The subjoined table shows the amount of honey I have succeeded in obtaining from my hives during the past six years, 1911-16, the period during which I have worked for honey, using the extractor whenever the accumulated stores in the hives justified my doing so. By noting the dates as given in column A, we can form an idea of the duration of the honey season. The dates are fairly regular and the season, in this part of Trichinopoly at least, may be said to begin

in February and to extend to August, with a break of a few weeks during the hot dry months of April and May.[1]

Column B gives the number of hives that held honey in sufficient quantity to be extracted, not the total number in the Apiary. Fresh swarms generally give no honey, or very little, the first year.

In column C we have the amount actually extracted, and in column D the total for the year.

Table showing the amount of Honey extracted during 6 *years*, 1911-16.

	A	B	C		D	
			lb.	oz.	lb.	oz.
1911.	28th February	..	3	8		
	14th June	......	7	0		
	26th ,,	...	7	0		
	13th July	.....	4	8		
	31st August	.. ..	3	4	25	4
1912.	7th March	5 hives.	6	8		
	27th ,,	3 ,,	3	5		
	14th June	4 ,,	6	0		
	26th ,,	1 ,,	5	0		
	9th July	3 ,,	8	8	29	5
1913.	20th February	3 ,,	8	0		
	24th March	4 ,,	6	0		
	25th June	6 ,,	17	8		
	2nd August	4 ,,	4	8	36	0
1914.	25th March	6 ,,	14	0		
	23rd June	5 ,,	16	8		
	22nd July	8 ,,	21	8	55	0
1915.	17th June	6 ,,	15	0		
	16th July	6 ,,	18	0	33	0
1916.	2nd March	8 ,,	18	8		
	29th ,,	5 ,,	8	8		
	5th July	3 ,,	18	0	45	0

I should be sorry if a perusal of the above table should leave in the mind of the reader a feeling of disappointment or discouragement. It is true that, compared with *A. mellifica* in other parts of the world, the yield of honey from the *A. indica* appears ridiculously poor. There seems to be no proportion between them. An apiary of a few dozen colonies in America, for instance, is expected to produce honey by the ton ; here with half a dozen colonies I am obliged to weigh it by pounds and ounces. A single hive of *A. mellifica* may give anything from 50 to 100 lb. or even more ; here the most

[1] There is no real winter in S. India, and the bees come in and go out of the hive the whole year round. A hive which I placed three years ago in the Cantonment, only two miles south of the College, has invariably stored honey in October and November, though at that time there is no honey-flow for the hives in the College garden. This would seem to show that in S. India the honey season varies greatly even in the same region.

ever obtained from one hive was less than 15 lb. and the average from a good hive works out to 8 or 10 lb. This may seem a very small reward for so much labour; nevertheless, the results in my opinion are not so poor that they should discourage us in our efforts to cultivate and improve the Indian Honey-bee. I firmly believe that, given a good locality where honey-yielding trees and crops are to be found in sufficient quantity, with proper hives and modern methods, the Indian bee in spite of its small size might prove sufficiently productive to justify its cultivation.[1] Bee-keeping is a most healthy and interesting occupation; one soon gets to know the ways of the little creatures and to take pleasure in watching them at work. It would be regrettable if people in the Plains of India, where the *A. mellifica* does not thrive, were to be for ever deprived of such a fascinating pursuit as bee-keeping from a mistaken notion that the Indian bee is not worth cultivating. After all, 40 or 50 pounds of honey extracted from a few hives of one's own, and known therefore to be pure and clean, is not such a despicable result, when we consider that the expenses are a trifle and the labour almost nil. But I am strongly persuaded that with proper scientific methods and more care the yield might be considerably increased. I certainly do not claim to have got from my bees all that I could have got from them, or to have given them as much of the benefit of the improved methods in modern apiculture as I might have done. Visiting them at odd moments in the scanty leisure left from a hard day's work, sometimes not going near them for days and weeks together, allowing them to swarm time and again without check and thus weakening the hives, having no spare combs or foundation comb to stimulate and facilitate their work—the wonder to me is that, in spite of such scant attention, they nevertheless gave so much.

If, however, the Indian bee is to be made more productive, there are several points to be attended to. The first is to try to

[1] In what I say here and elsewhere of bee-keeping in India, I speak of it only as a secondary and subsidiary industry, and quite endorse what Mr. Bainbrigge Fletcher says:—"In any case bee-keeping can only be recommended as a supplementary source of income and not as a sole means of livelihood." (*Agric. Jour. of India*, Oct. 1911, p. 398.)

improve the stock. Bees, and especially queens, differ greatly in character and quality. Some are good and others poor; some are industrious and prolific, others gather little and increase but slightly. A good queen makes a good hive. One hive I have now had for over six years, and it is still the best hive in our apiary. Year after year it has remained strong, and still produces the largest crop of honey. It is from such hives that queens should be raised for the use of fresh colonies. Then again swarming should be controlled, or kept under check so as to prevent after-swarming. In this way we should avoid finding the hives depleted and weakened and falling a prey to the wax-moth and other enemies. If these and several other points are properly attended to, I cannot but think that our little Indian bees would soon win for themselves a better name.

An objection that is sometimes brought against the domestication of the *A. indica* is its supposed "vagrant disposition," its tendency to leave the hive after a time and take to a wild life once more. Mr. Bainbrigge Fletcher in that most interesting and useful work, "Some South Indian Insects" (Chapter XXII, p. 210), says: "*A. indica* can be, and often is, kept in a more or less domesticated state in hives, in which, however, it rarely remains more than a few months, thereafter swarming off to found a new nest, and this vagrant disposition is one difficulty in keeping these bees, as new colonies have to be obtained frequently, or at least the old ones re-caught and re-hived." And in his article on "Bees and the Fertilization of Coffee," he repeats the statement. Now it is quite true that many swarms do abandon their hives, sometimes after a few months, sometimes only after a year or several years; and we are consequently often put to the trouble of looking for new swarms if we wish to keep the apiary at its strength. But is this due to any innate "vagrant disposition" of the bees, or is it not rather due to the conditions of the hives in which they are kept, or perhaps to scarcity of food? After many years' experience during which I have had to deplore dozens and scores of such "flittings" on the part of the bees, I have come to the conclusion that the fault is not in the bees but in the bee-keeper, who at times is perhaps not as attentive to their wants as he ought to be; and that if the hives

are only properly designed, not too large, but capable of being storied up and reduced so as to give the bees exactly the space they require and no more, and again if they are given artificial food, when their natural food is lacking, then the Indian bee will show no inclination to exchange its comfortable modern hive for an old hollow tree. I regret not having kept a record of each of the hives I have had in the past. It would probably have shown that the Indian bees, once fairly settled in their hive and busy with their combs and brood, seldom leave unless forced to do so. My strongest hive, as I have just said, has been with me for more than six years ; I have three others which have stayed three or four years and they are very strong. I seldom lose a hive nowadays except when I happen to be away during the swarming season and fail to reduce such hives as have swarmed. The consequence is that the bees, too few to cover all their combs, allow these to fall a prey to that universal pest, the most terrible foe to apiculture in India—the wax-moth. This, as everyone knows, is the caterpillar of a small moth (*Galleria mellonella*) which, on emerging from the egg, works its way through the cells feeding on the wax, and soon covering the entire comb with its threads. Once it has begun to spread, the bees are powerless to arrest its progress and the whole comb becomes a tangled mass of threads, grubs, cocoons and dirt. The bees are thus forced to leave the hive. The wax-moth generally finds an opportunity to enter the hive and deposit its eggs whenever for some reason or other the bees are no longer numerous enough to cover their combs. This may happen either in the swarming season, when one or several swarms have left the hive and reduced the population overmuch, or at the close of the season, in the beginning of the cold weather, when the rearing of brood has stopped and a large number of bees die off. On either occasion the bee-keeper must be alert to notice the diminution in the strength of the colony and must reduce the space proportionately. In this way with careful attention there seems to be no reason why colonies should not be preserved for many years.

From what has been written so far, I hope to have shown that the case for the Indian Honey-bee is not so hopeless as is generally

believed. By using proper hives, by improving the quality of the bees, and by preventing excessive swarming, the yield of honey per hive might certainly be increased; while, on the other hand, by carefully watching over the hives, and not giving them more space than they require, a good deal at least of the ravages of the wax-moth might be prevented. There still remains, however, an important factor to consider in connection with the yield of honey. This is the abundance and character of the vegetation in the neighbourhood of the apiary. Naturally bees cannot give more honey than they themselves can find. The first question, then, to consider before starting with bees is whether the country around can support an apiary, that is, not only supply the bees with the necessary food, but over and above their food provide them with so much honey that they will be stimulated to build and breed and store up surpluses. On the Hills and the Coffee Regions there would seem to be no need for anxiety on this score. Mr. Bainbrigge Fletcher mentions single trees in Coorg being the habitat of 100, or even 156, colonies of *Apis dorsata.* Evidently then there must be honey enough in those regions for very large apiaries.[1] But in the Plains this may not always be the case. In many parts of the country there would appear to be a scarcity of nectar-yielding plants, or at least not a sufficient abundance of them to enable the bees to store up an excess of honey over and above their own needs. Unhappily my experience on this point is very limited. It is confined to the fields and gardens round Trichinopoly. In Trichinopoly there are a certain number of mango-topes within and just outside the town, and it is in February and March, when the trees are in blossom, that the bees begin to store and the extractor can be used. In 1915 the mango-crop in Trichinopoly was a complete failure and the result was that no honey could be extracted during the first part of the season. This year (1916) the mango-crop has been exceptionally good, and I extracted 27 lb. in March alone. This would show that during the

[1] It should be noted, however, that these bees are said to migrate to the Plains during a part of the year in search of food. This seems to imply great abundance of food at one time followed by a long period of scarcity, and it might be doubted whether an apiary of *A. indica* would thrive under these conditions, unless the bees were fed artificially.

first part of the season my bees depend for their surplus entirely on the few mango trees in the vicinity. In the same way the large crop usually extracted in the months of June and July seems to be derived mostly from a few Indian cherry trees (*Eugenia jambolana*) and acacias. When these have bloomed, the honey-flow ceases and the season is over. The bees continue to work, they fly in and out of the hive the whole year round, even during the rains and the cold weather, but do not store; they still visit plants and trees that yield them honey, but in small quantities only, barely sufficient for the needs of a much reduced hive; and the combs are almost empty, containing just a trace of honey and pollen, and no brood.

I do not know whether observations have been carried out in India to ascertain the trees and plants frequented by bees. It would be interesting and useful to know what plants supply them with honey, and what with pollen. Here is matter for study for any enthusiastic botanist who would like to apply his knowledge to some useful purpose. Again, here in Trichinopoly, where the country mostly consisting of rice-fields, would seem not over-rich from an apicultural point of view, with very little trouble I can get some 7 or 8 lb. per hive: would it not be possible to obtain at least double that amount in regions where the vegetation is more abundant and more favourable, supposing the hives are properly looked after and worked upon scientific principles? It would at least be worth trying.

I will now pass on to describe the methods I have found most successful for securing swarms and the type and size of hives that I use.

How to obtain fresh colonies.

In the early days of our experiments our method of obtaining bees reminded one of the recorded Chinese method of securing roast pig. When coming across a swarm in a hollow tree, our procedure was to cut the tree above and below the swarm, and carry away the hollow portion with the bees and combs. Some days later, when the bees had grown accustomed to their new surroundings, the combs would be cut out, placed in frames, and the bees shaken into the hive. It was a laborious and expensive method, frequently necessitating the cutting down of large trees for the sake of a swarm

which often enough, after all the cutting and sawing, would leave us shortly after. Moreover, hollow trees began to grow scarce in the neighbourhood. But the idea soon dawned upon us that we might make use of these hollow pieces, which we had cut off, to capture new swarms. We tied them up among the branches of trees which bees were likely to frequent for the flowers. Generally we had not long to wait before the bees found out the lodgings prepared for them and came and took possession. Nowadays we have gone a step further : instead of using hollow trunks, we hollow out logs ourselves. The best trees for the purpose are dead coconut or palmyra trees (Plate III, fig. 2). These are sawn up into pieces 15 inches long or more, and should be 9 to 12 inches in diameter ; the interior is hollowed out to give a space at least 6 inches across, and thick deal boards are nailed above and below so as to close both ends completely ; a hole, or, better, several small holes, are cut out on one side to serve as entrance for the bees. The various logs are then placed in a position where they are likely to be found by the bees (Plate IV, fig. 1). New logs may take some time before they are discovered, but logs which have already been tenanted and in which there still remain traces of combs or a faint smell of wax and honey will attract swarms rapidly. It is useful to inspect the logs occasionally for nests of squirrels or rats, as these mischievous little pests are inclined to think that the logs have been put up for their special benefit. After the log has been taken possession of by a swarm (Plate IV, fig. 2), it is advisable to leave it undisturbed for about three or four weeks. By that t'me the first batch of brood will have been hatched out, and the thin silken cocoons lining the cells will have given greater toughness to the combs, making them less liable to be crushed or broken when taken out.

To transfer the swarm to a hive, the log is turned gently on one side, the bottom board prized up without too much shaking, and the combs taken out one by one. Smoke may be used to drive the bees off the combs, but generally the mere shaking and opening of the log will have caused them to cluster at the top leaving the greater part of the combs exposed. The latter are now cut to the required size and fixed in the frames. To fasten them, the best



Fig. 1. Partial View of the Apiary, St. Joseph's College, Trichinopoly.

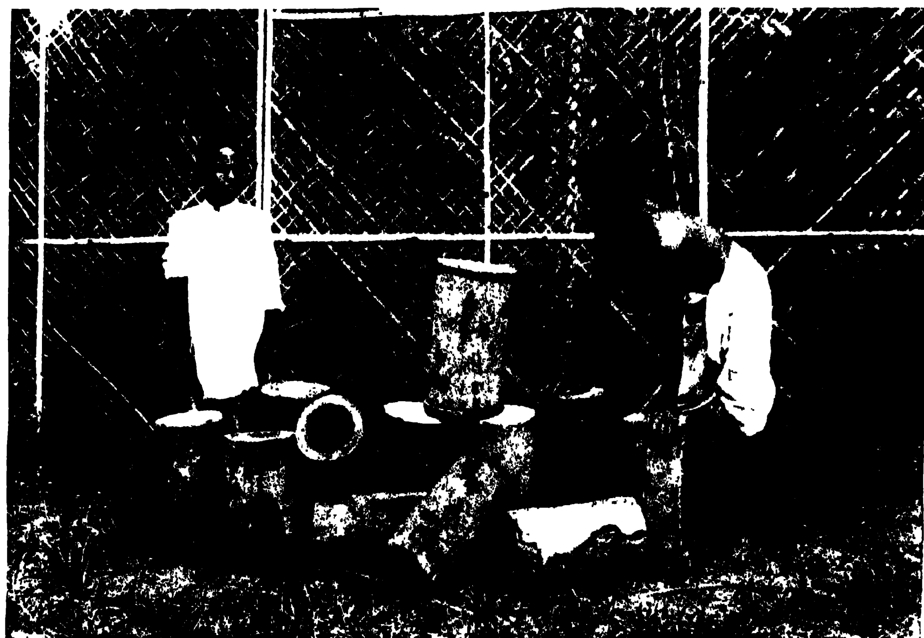


Fig. 2. A good supply of Bee-Logs.



Fig. 1. A Bee-log on the tree.



Fig. 2. Combs in a Bee-log



Fig. 3. Transferring. Tying the combs to the frames.

method I have found, after trying wax, wire-fasteners, string, etc., is to use small strips of fibre from the dead leaves of the plantain tree. These, about ¼ inch broad, I first moisten to make them less brittle, then tie round the combs and above the top bar of the frame. They hold the comb very well without cutting through the wax and do not seem to irritate the bees so much as string. In one or two days, when the bees will have fastened the combs with wax, the plantain strings can easily be removed. After fixing the combs in the frames, and placing the latter in the hive, the bees are shaken into the hive which is covered over immediately. If everything has been done properly and the combs well fixed, there is little danger of the bees absconding. Bees do not willingly abandon combs and brood so long as these are in good condition (Plate IV, fig. 3).

Hives and Frames.

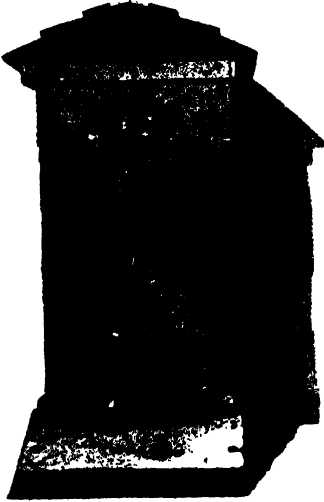
The first point to be settled, before determining the size of the hive, is the size of the frames that are to hold the combs.

It has been recommended for the sake of uniformity and other obvious advantages, that all bee-keepers should conform to the standard size of frame 14 × 8½ inches. Undoubtedly it is very desirable that in India, where bee-keeping as an industry can hardly be said to have begun as yet, a proper start should be made with standardized frames and hives. But the frame selected as standard should at the same time be the one best suited to the combs of *A. indica*, and these, it must be remembered, are very much smaller than the combs of *A. mellifica*. It would seem to follow therefore that the frames of *A. indica* should be proportionately smaller than the European standard frame. The latter, in fact, appears to me altogether too large and quite unsuitable to our Indian bees. Some years ago the frames we used in our apiary were 12 × 6 inches in size, but even these, though smaller than the standard frame, were discarded as being too large. We now make use of two different sizes of frames, one for the brood chamber, 8 × 5½ inches, inside measurement, and the other for the honey-frames in the supers, 8 × 2½ inches. The disadvantage in using very large frames, say, of the standard size, is that, as far as my experience goes, very few

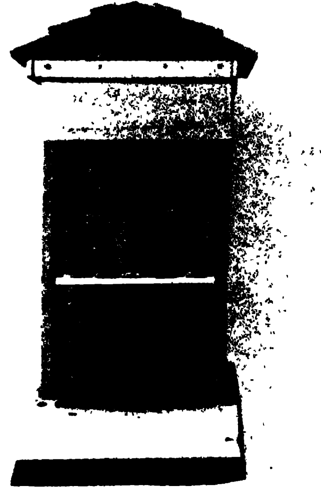
colonies of *A. indica* will be found strong enough to cover more than 3 or 4 of such frames, when first hived, and the result will be an amount of empty space in the hive, providing free lodgings for the wax-moth and other pests. Another disadvantage is that the bees, unable to provide sufficient brood to fill such large frames, will store up honey in the same frame side by side with the brood, making extraction impossible. It was by considerations such as these, and by observing the average proportion of brood-comb present in an ordinary good swarm, that Father Bertram in his experiments with bees in the Hills finally fixed on the sizes of frame mentioned above, and these I afterwards adopted for all my hives. Placed side by side with standard frames, ours may appear absurdly small, but they have been found very practical, and for the present I think that it would be a mistake to try to make them larger, at least to any considerable extent. Bee-keeping in India is still in the experimental stage, and it is probable that, as our experience increases, we may come to develop stronger colonies. It may then be possible to fix on a frame slightly larger than the one mentioned above, but I do not think it will ever reach even approximately the standard frame size.

To come now to the hive itself, I have experimented and am still experimenting with hives of two different sizes, and find it hard to say which is to be preferred. There is something to be said in favour of each, and for the present I prefer to keep both kinds at hand, ready to use the one most suitable to each colony. Our earlier hives were built to contain six frames, $8 \times 5\frac{1}{2}$ inches, in the brood-chamber, and over this were piled up, as required, one, two, or three supers with frames $8 \times 2\frac{1}{2}$ inches for honey. But Father Bertram, who had had to deal with good strong colonies in his apiary at Shembaganur, urged on me the many advantages of a larger hive with 8 or even 10 frames, and at last I made up my mind to try one with 8 frames. I found the change an improvement in several cases and have since used 8-frame hives for a number of colonies, with good results, though for others I have been obliged to keep to the 6-frame hive (Plate V). There is always the same objection against overlarge hives as against large frames. Though they may do very

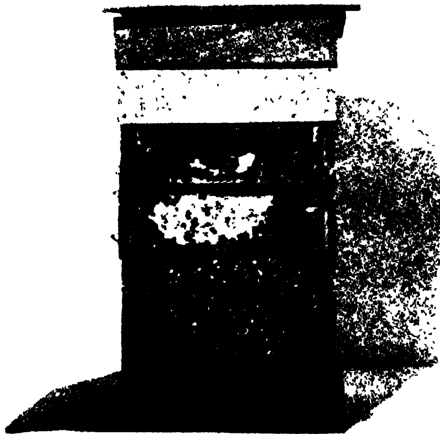
PLATE V.



A 6-frame Hive.



The same, front view, showing bees and frames.



The same, side-view, showing bees and Combs

well for big colonies, they increase the danger of the wax-moth if the hive starts being reduced through swarming or any other cause. On several occasions to save a colony I have been obliged to retransfer it from the 8 to the 6-frame hive. On the other hand, an advantage of the 8-frame hive, which must be mentioned, is that it tends to keep colonies strong and to strengthen them still more. It gives more space in the brood-chamber, and so encourages breeding. If the bees in a swarm are numerous and hard-working and the queen prolific, an 8-frame hive should be used.

I had intended, in conclusion, to add a few directions for the benefit of those among my readers who might desire to start an apiary. But since writing the above, I find that such directions have already been given at length, and much better than I could have given them, in a recent Bulletin of the Agricultural Research Institute at Pusa.[1]

I cannot conclude better than by referring my readers to that very practical treatise on bee-keeping. I will merely add a remark on the methods there described of procuring the colonies to start an apiary. Three methods are given: (1) using decoy-hives, (2) capturing swarms, (3) hunting out bees in cavities of trees and walls. The second and third methods, though good and feasible for one who is acquainted with bees and knows when and where to look for them, may possibly not prove so useful to a beginner. For him the first method, with decoy-hives, will probably be found the most practical, and the most likely to secure colonies quickly and with little trouble. Instead of hives, logs (as described on page 52) might be used: they are cheaper and not so liable to be spoilt, or stolen. A large number, one or two dozen, can easily be prepared and scattered about the country, and the bees that come and occupy them can later on be transferred with their combs into the hives prepared for them.

NOTE. I showed the above article to Rev. Father Bertram, S. J., and in reply received from him the following notes which appear sufficiently interesting to deserve publication.

[1] "Bee Keeping," *Pusa Bulletin* no. 46.

NOTES ON THE HILL VARIETY OF *Apis indica.*

On the Palnis the Indian Bee (*A. indica*) is very plentiful. The number of wild colonies is extraordinarily great. In less than one year we found no fewer than 50 within a radius of a few furlongs nearly all in holes in the ground.[1] They also take kindly to logs as their sisters in the Plains. Some of these colonies even in the wild state are very strong. I remember several which, judging from several weighings I made, I believe to have been 80,000 strong.

At first sight one would be tempted to accuse them of a tender y to vagrancy, like the yellow Indian bee of the Plains. I recollect one newly-hived colony attempting nine times to escape, three of which attempts were made within one day. As we had clipped the wings of the queen, the bees returned to the hive every time, the queen being unable to follow them. They made a tenth and last attempt, but this time they killed the queen before leaving, flew away, and never came back. From observations made on a number of colonies I can say that this absconding seems rather the result of the circumstances in which they find themselves, as when they are driven away by famine or attracted elsewhere by an abundant crop. Some colonies remained with us several years and yielded honey fairly regularly, but I am sorry I have kept no record of the yearly yield.

I have a number of facts to prove that queens, laying queens, leave the hive and go out occasionally, presumably for an airing. Our custom of clipping the wings of our queens made control of their movements easy. Thus on one occasion we had two colonies placed on the ground four or five feet from one another, one very strong (one brood-chamber of eight frames and three supers, the whole hive full from top to bottom), the other very small, in fact a handful of bees, the queenless remnant of a run-away hive. One day we found in the queenless small hive a queen which was unmistakably the queen of the large colony. Another day I found the queen of a prosperous hive crawling on the road about fifty feet from its nest.

This black Hill variety is, generally speaking, very tractable. I attempted twice to transport the yellow *A. indica* from the Plains to the Palni Hills, taking several colonies housed in logs. The first

experiment was made at Kodaikanal (7,000 ft.). Within one day all the bees had died of cold. The queen alone survived, flying about in distress till late in the evening when I lost sight of her. The second time I got a log full of bees brought up to Shembaganur (6,000 ft.). The little things kept very lively, but at once started pillaging the other hives and fighting the black bees. They were very mischievous and would not stay. We clipped the wings of the queen, but nevertheless they went away. A few days later we found a cluster or two of them, and tried to mix them with the black bees, but these would not admit them. We tried also the converse experiment. We brought down black queens with a few bees from Kodaikanal to the Plains, and introduced them into colonies of yellow *A. indica*, but very soon after found no trace of them in the hives. I would not however give these experiments as conclusive. They were conducted on rather simple lines. The question remains open whether more careful methods would not succeed.

[*Note.* As regards the sizes of hives and frames suitable for *Apis indica*, we have kept this bee in (1) standard-size hives with frames 14 × 8½ inches, (2) in kerosine-box hives with frames 11¼ × 8½ inches, and (3) in special small hives with frames 8½ × 5 inches and with a super of similar capacity. This last is almost the same size as that (8 × 5½) recommended by Father Newton, but the slight difference in dimensions would prohibit interchanging and thus would fail to attain that standard of size which is correctly laid down as necessary. Our experience however, is that, in a small hive with frames only 8½ × 5 inches, the colonies seem to accommodate themselves to the capacity of the hive and, as they do not work so well in the supers as when they all live together in the same chamber, they do not show a proper tendency to strengthen the colony. We consider that the best hive for *Apis indica*, at least for the variety found in the Plains of India, is the kerosine-box hive, with frames 11¼ × 8½ inches, as described on pages 31—39 of *Pusa Bulletin* no. 46; the size of the chamber can be increased or reduced, to suit the size of the colony, by the use of a division board and for extraction of honey the queen-excluder dummy should be used.

The conditions at Trichinopoly may be special to the locality and the sizes of colonies perhaps unusually small owing to lack of regular pasturage, but our experience with *Apis indica* at Pusa, where ample pasturage is obtainable throughout the year, seems to show that these bees will do much better even in standard hives (with frames 14 × 8½ inches) than in those of the small type described by Father Newton. In standard hives the bees do not fill the entire frame with comb as they do in the kerosine-box hives. The wall hives, recommended for use in the Hills, are even larger than the standard hives.—T. Bainbrigge Fletcher, Imperial Entomologist.]

THE IMPROVEMENT OF THE SEED SUPPLY IN THE CENTRAL PROVINCES.*

BY

G. EVANS, M.A. (Cantab.),

Deputy Director of Agriculture, Northern Circle, Central Provinces.

The raising of the out-turn of crops is one of the most important problems that faces the Agricultural Department in India and has always been recognized as of fundamental importance. As a natural result it occupies a prominent place in the programme of every Provincial Agricultural Department.

This problem is being attacked in various ways and varying degrees of success have been obtained by :--

(1) Introduction of better varieties.

(2) Better methods of tillage usually accompanied by the use of improved implements.

(3) Manuring and irrigation, etc.

The first of these has perhaps received the most attention in the Central Provinces and has up to the present given the most noteworthy results. The reason probably is that it is a method of improvement in which results can be obtained quickly and which requires comparatively little staff. The latter is an important consideration in these Provinces, where the development of departmental activities is still greatly hampered by lack of trained men.

In this article, therefore, I wish to describe briefly the measure of success that has so far been achieved in improving the seed supply and the methods which have been adopted, basing my

* Received for publication on 17th October, 1916.

remarks largely on the results which have been achieved in the northern parts of the Central Provinces in which I have worked for the last ten years.

In the first place it is necessary to emphasize the fact that the introduction of exotic varieties has, with few exceptions, proved a total failure. A certain amount of success has been achieved in establishing foreign groundnuts, especially the small and big Japanese varieties, but these have come in as a new crop in places where the cultivation of groundnuts was formerly unknown.

No exotic varieties of staple field crops have so far made any headway and all improvements have so far come from within so to speak, by the careful selection or hybridization of local varieties. Thus the *roseum* cotton which Mr. Clouston has so successfully introduced into Berar and which is now grown on thousands of acres is simply a selection out of the local *jari* cotton. All the attempts which had formerly been made to introduce long staple foreign varieties such as Upland Georgian, *buri*, etc., have failed because they cannot compare in yield, hardiness and general adaptability to local conditions with the local indigenous varieties. In the same way in the wheat growing tracts of the north of the Provinces the peculiar local conditions of soil and climate are such that no degree of success has yet been achieved in introducing foreign varieties or even, with few exceptions, varieties from other parts of India. Occasionally a foreign wheat is used for crossing with a local variety in order to obtain some particular character such as strength of straw, resistance to disease, etc., but generally speaking all the improved wheats which have been issued so far are the result of selection from local wheats. It is highly probable therefore that for some time to come and until much more advanced methods of cultivation are practised, we shall have to look to our local crops to provide the improved types.

Another point which requires emphasis is that as soon as a new type has been thoroughly demonstrated and proved better than the local variety a big demand for seed arises. The applications for seed of an approved variety far exceed the supply from Government Farms and arrangements have to be made to try and meet

the demand. The Indian ryot is no fool and once you have proved to him that a new variety is better than his own, he at once scraps the latter and demands seed of the new kind.

A typical instance of the way in which the innate conservatism of the cultivator may be overcome will serve as an illustration. In the Hoshangabad District and parts of the neighbouring districts a kind of *rabi til* (sesamum) is grown which has a dark brown seed and fetches an inferior price as the quality of oil produced is not particularly good. A yellow seeded variety is grown in the Nagpur country which is of far superior quality. The latter when grown at Hoshangabad gave at first a poor yield, but by careful selection a variety was obtained which after two years' testing was found to give a higher profit of Rs. 5 per acre owing to its quality and higher yield. Members of the local Agricultural Associations were first persuaded to try the seed and next year they grew it on a larger scale. The local markets did not know this variety and it was necessary to collect all surplus seed and send a trial lot to Bombay for marketing. Good prices were obtained and next year the area extended slightly in the neighbourhood. A local merchant was persuaded to give a small premium, an advertising tour was made in the villages near this market and arrangements made to supply seed. That was four years ago and the area sown was about 100 acres. **This year the area sown is not less than 50,000 acres and the extra money brought in the district from this source alone is about 2½ lakhs of rupees.** Furthermore the cultivators are realizing the dangers of deterioration through cross-fertilization with the local variety, against which they have received warning and in many villages now no cultivator is, by common consent, permitted to grow the *deshi* variety. Thirteen privately-owned seed farms have been established. They belong to members of the local Agricultural Association and renew their seed every year from the Government Farm, selling off the whole of their stocks annually to the local cultivators for seed purposes. In the Government Farm itself single plant selection is yearly carried on and better types are being raised, which automatically go out into the district through these seed farms.

The rapidity with which the improved *til* was introduced was largely due to the small amount of seed required to sow an acre, *viz.*, 3 lb. As a *til* crop will produce on the average 300 lb. per acre it will be seen that the rate of expansion possible is great.

In the case of other crops, however, where the seed rate is high, the difficulty lies in the supply of sufficient seed. In wheat for instance 100 lb. seed are required to sow an acre and the produce is rarely more than 600 lb. so that the rate of progress possible is necessarily much slower.

As considerable progress has been made in improving the wheat seed supply it may prove interesting to mention some of the measures employed.

New varieties are raised on the Government Experimental Stations at Nagpur, Hoshangabad, and Jubbulpore and are carefully propagated and observed until there is sufficient seed to test on a field scale, a process which takes from four to five years. Formerly an attempt was made to obtain a variety uniformly suitable for all parts of the wheat tract. This was speedily proved to be impossible, however. The Central Provinces is a country of various geological formations and consists of a series of high plateaux and deep valleys, so that considerable variations of both soil and climate exist. It was therefore found necessary to institute seed-testing plots for each of the considerable wheat tracts in which to test new varieties There were ten of these seed-testing plots last year. Some were on private land lent by the zamindars, in others the land was acquired or rented by the Department. In every case the plots were sown, cut and weighed by an officer of the Department and the opinion of the local agriculturists was freely solicited.

These plots act as valuable adjuncts to the Experimental Stations and seed of a good variety is immediately in great request. The results of testing on these plots have shown that one uniform variety will not do and we are now introducing special wheats into the various tracts such as the Satpura plateau, the embanked *haveli* of Jubbulpore and Narsinghpur and the lower Nerbudda valley.

The demand far exceeds the supply and every year the struggle for seed increases. Probably not less than 200,000 acres will be sown

with pure wheat varieties this year which will bring in an extra profit to the growers of about nine lakhs of rupees.

As the new types are pure and the local wheat is a mixture of several varieties some difficulty is at first felt in obtaining a proper premium and therefore efforts are concentrated towards introducing a new type first of all in the neighbourhood of a local grain market which has direct dealings with Bombay or Calcutta. As soon as the area increases and the pure wheat is offered in quantities of a wagon load or more, little difficulty is experienced in getting a premium but it often takes a year or two to get the fair price. In Betul where selected Pissi wheat is now grown on 15,000 to 20,000 acres a premium of only two annas a maund is yet obtained but as competition in this backward market increases a premium of four annas equal to that paid at Itarsi, which is in direct touch with Bombay, can eventually be expected.

Various agencies have been tried as a means of introducing new seeds. They may be briefly classed as follows :—

(1) Co-operative Banks.

(2) Seed Unions.

(3) Private Seed Farms.

Co-operative Banks. Co-operative seed unions may be formed of groups of Credit Societies which borrow money from the Central Bank and purchase seed of the new wheat. They store their seed in a common pit each year and every member pays back into the union fund at harvest time, the amount of grain he has borrowed plus 25 per cent extra as " Sawai." This " Sawai " is used partly to pay off the interest on the bank loan and partly as rewards for the union servants, incidental expenses, dividends, etc. These unions have been tried now for three years and there are various practical difficulties in the way of their smooth working. As a result the Registrar (Mr. H. R. Crosthwaite) and myself have come to the conclusion that the best way is to deal with the Bank direct. When Societies come to borrow money for the purchase of seed grain, they are now recommended to go in for the new type and are told where they can get it. They are advised to store their seed in a joint pit and to keep it pure. In actual practice it seems likely that they will carry

out these instructions when they find that the pure seed fetches a higher price than mixed. As an instance of what can be done it may be mentioned that the Crosthwaite Central Bank, Ltd., Sihora, supplied 2,656 maunds of selected seed to 53 Societies in 1915. The same process has been adopted by the Betul Central Bank where 14 Societies were supplied with 620 maunds of Pissi No. 13 in 1915 and the demands of over 50 Societies are being dealt with this year.

Seed Unions. A Seed Union consists of individuals who are not as a rule members of a Co-operative Society. They are mostly substantial tenants or small *malguzars* who co-operate to purchase or hire a suitable piece of land and start a seed farm for some particular variety of wheat or other crop. The seed is obtained fresh from the Government Farm each year and each member is entitled to a certain proportion of the produce which he utilizes for sowing on his own land.

These Unions promise to be an efficient way of providing seed to a class which is otherwise difficult to get in touch with. Six Unions were at work last year and the movement seems likely to extend.

Private Seed Farms. These are the property of substantial *malguzars* with extensive home farm cultivation. They have the first call on the seed of a new variety from the Government Farm and in return they agree to carry out certain simple rules which insure that their seed is kept pure. They allow the Department to have the first call on their produce and agree to inspection by duly qualified officers of the Agricultural Department. Seed farm owners, whose produce is passed as pure, are awarded a seed farm certificate of purity and find it of great assistance when selling their produce for seed purposes.

These seed farms usually sell all their produce for seed purposes as the demand is very keen. Their chief customers are the Central Banks, Court of Wards, and private estates and they also loan a large quantity of seed to their own tenants. Last season eighty-five wheat seed farms were inspected. Many were disqualified as they did not reach the minimum acreage required, *viz.*, 50 acres. Thirty-nine seed farms, however, with a total acreage of 4,800 acres received the certificates.

CONCLUSION.

In conclusion it is very certain that we shall want more Government Seed Farms in the near future if we hope to be able to cope with the seed supply. At present no more private seed farms can be started as there is no more Government seed available. There is no doubt that we want a Government Seed Farm at each district head-quarters at once and we shall very soon want one for each Tahsil as well. An Experimental Seed Farm has been started at Betul and is now in its second year. It deals with the wheat and cane crops chiefly. The whole of the produce of the Farm is earmarked for fifteen private seed farms of the type described above. Each owner takes sufficient wheat seed to sow one-sixth of his area each year. This is threshed separately and is reserved for sowing his seed farm next year. The produce of his farm is available for sale to :—

(1) Co-operative Societies through the Central Bank.

(2) To his tenants on sale or " Sawai."

(3) To the general public in the district.

Last year these seed farms grew ordinary mass selected pure Pissi. This year they are growing an improved type No. 13 on one-sixth of their area, while the Government Seed Farm is growing a still better type No. 85, which private seed farms will receive in 1917.

This system is simple and affords a definite channel for introducing new varieties rapidly into the district. The Government Seed Farm is in charge of an Agricultural Assistant and another Agricultural Assistant is in charge of demonstration work in the district and is responsible for the proper management of the private seed farms.

It is hoped to extend this system to all the districts in the Northern Circle of the Central Provinces as soon as the necessary funds and staff are available.

A NOTE ON DOURINE IN THE HORSE.*

BY

COLONEL H. T. PEASE, C.I.E., V.D., I.C.V.D.,
Principal, Punjab Veterinary College, Lahore.

INTRODUCTION.

THIS disease, commonly named in the East Dourine, is a specific disease of the horse and ass caused by a trypanosome and spread by Coitus.

It is, therefore, confined to breeding animals and on account of its insidious nature and serious effects is of great importance, so far as the horse-breeding industry is concerned.

I discovered a severe outbreak of the disease amongst the stallions of the Horse-breeding Department in 1902, but energetic measures stamped it out in all the districts in which it was known to exist, and no cases have occurred in them until quite recently, when a few cases appeared in the Dera Ghazi Khan District which enquiry showed had been introduced from Baluchistan where the malady was not known to exist in 1902.

It now appears that the disease prevails to a large degree in Baluchistan and hence the present note may prove of interest.

Trypanosomes are Protozoa of the class Flagellata characterized by the possession of a fusiform body more or less elongated, with at one extremity a flagellum which is continued along the body of the parasite as the thickened edge of an undulating membrane. The body is composed of protoplasm. There is a nucleus situated about the middle of the body, and a small chromatic body which is called

* Received for publication on 16th November, 1916.

the centrosome is situated quite near the end opposite to the free flagellum.

Along the upper part of the body and bounded above by the flagellum which starts from the centrosome is a thin membrane, the undulating membrane. The flagellum in animal trypanosomes often extends a short distance beyond the body, forming a free flagellum. Movement is secured by the lashing of the flagellum which actuates the undulating membrane.

The animal trypanosomes multiply by longitudinal division in the blood or lymph. Like other animal parasites, they often effect a robbing action on the host. They excrete toxic material and in some cases give rise to local chronic inflammations. They usually appear in crops which die off for the most part to be succeeded by another crop.

The common trypanosomes of the horse in India are :—

(1) *Trypanosoma evansi* causing Surra.

(2) *Trypanosoma equiperdum* causing Dourine.

Nature of the Disease.

As already stated Dourine is due to the entrance into the system of a trypanosome named *Trypanosoma equiperdum.* This parasite was first discovered at the remount depôt at Constantine by Rouget in 1894. The strain of virus which he was dealing with appears to have been of exceptional virulence. Schneider and Buffard again found the trypanosome in horses and donkeys and reproduced the disease in the horse by the parasites passed through the dog in 1899. The virulence of their parasite was less than that found by Rouget and they were inclined to think that the latter had been dealing with another trypanosome. The great variation of virulence of the trypanosome in different countries especially in regard to its effects on inoculated animals greatly discounts Schneider and Buffard's contention. Laveran and Mesnil agree that Rouget was dealing with the Dourine trypanosome. Doflein named the parasite *Trypanosoma equiperdum* in 1901, a few days before Laveran and Mesnil suggested the name *Trypanosoma rougeti*, so the former must, according to the law of priority, stand.

In regard to the measurements of the trypanosome of Dourine there is some difference of opinion. Laveran and Mesnil make it 25 to 28μ long. The longest example found in India was 35·8μ. The mean in the vaginal mucus was 22μ, the longest found being 31·28μ. The variations in size were so great that it was at one time thought that more than one variety of parasite was being dealt with. The average breadth is 1·48μ mean, the maximum being 3·32 and the minimum 0·85.

In ordinary fresh preparations the parasite resembles the Surra parasite *Trypanosoma evansi* from which it cannot be distinguished morphologically. It stains fairly uniformly but perhaps a little less deeply than the other and possesses usually no chromatic granules. The only form of division so far seen in this country is that by longitudinal division. Laveran and Mesnil talk of trypanosomes with 6 nuclei two of which were still dividing. Rabinowitsch and Kempner talk of parasites with 8 or 10 nuclei arranged in the form of a rosette. Possibly, too, one of Schneider and Buffard's figures represents a similar case of multiple division.

Vitality of the parasite.

Trypanosoma equiperdum appears to be a strict parasite. It retains its motility only for a few hours in the blood outside the body; but Laveran and Mesnil have seen it remain motile for 48 hours in a sealed preparation kept at a temperature of 36°C. Schneider and Buffard found that the blood of an infected animal is non-infective after 24 hours and this is our experience in India. The trypanosome is said to retain its virulence for three days when mixed with citrate solution and kept in the refrigerator. It keeps for two days in defibrinated blood and for only one day after the addition of horse serum.

History.

The following is a brief sketch of its history. The first notice of the disease is that given by the German Veterinarian, Ammon, in 1796, and again in 1799, he observed it in the district of Trakehnen, North Prussia, affecting mares and stallions. It persisted in this

locality until 1801, when Count Lindenau, master of the horse to the King of Prussia, caused it to be carefully studied by Reckleben, and two years afterwards (1803), Ammon and Dickhauser gave an excellent description in *Tennecker's Gazette* (Vol. III). From 1801, the malady disappeared from Prussia, but extended northwards, causing much loss in Lithuania, and returning again to Trakehnen in 1807, where it once more came under the cognizance of Ammon.

Such is the early history of the disease ; but it was believed to have been seen in Southern Russia before this period, and Renner mentions that it prevailed among the horses in the Imperial Stud at Skopin and in the Government of Kazan, Pottchinkoff and Nischnei-Novgored, where it was studied by Kersting, and to which it is said to have been brought by English stallions. It may be mentioned, however, that doubts have been entertained as to the reliability of Renner's statement.

In 1815, Woltersdorf, Veterinary Surgeon of the Bomberg District, Austria, observed it in the neighbourhood of Wanhau ; and Havemann, Director of the Veterinary School of Hanover, remarked it in 1816 in a stallion in the vicinity of Blockley, Hanover. This animal infected several mares, which, in their turn propagated the malady ; so that it prevailed in that country until 1820. In 1817-18, it again showed itself in Lithuania and re-appeared in 1819 towards the Austrian frontier, at Oberschliessen, district of Liebschutz. It showed itself in 1821 near Steiermarck and Pharau, where it attacked a large number of animals ; it also broke out in Silesia and at the stud of Lembus. In Styria, it pursued its course as a veritable epizooty.

In 1826, it re-appeared in Silesia in a small number of animals and in benignant form. From 1827 to 1830, it caused a great mortality in Bohemia ; and in the spring of 1830, it appeared for the first time in Switzerland, in the Canton of Berne.

In 1833, it again broke out at Oberschliessen and manifested itself in provinces of Liebschutz and Oeltz in Upper Silesia : in 1836 it was particularly severe in the latter province, in the districts of Striegau, Oeltz, Grotthau, Beissz, Fauer, and Friestadt.

Pomerania was visited with benignant form in 1839, and in 1840 it re-appeared in Silesia on an extensive scale, and in a malignant form, in the districts of Bartenstein and Schippenbeif; and again in that country in 1841, at which period it was seen at Gumbinnen in Lithuania. In Wurtemberg some mild cases were observed.

The disease had now assumed such serious proportions and was causing so much alarm in the stud-farms and among private horse-breeders, that several legislative enactments were adopted and enforced; at the same time Veterinary Surgeons were beginning to devote their energies towards investigating its nature and the most efficient prophylactic measures to be devised against it. These checked its progress in Germany, and the cases that subsequently occurred were less serious.

In 1847, it was reported in Algeria by the French Military Veterinary Surgeon Signol, who saw it in the province of Constantine, and who described it as an "Epizootic Paraplegia" that had appeared among the horses of the Rigas tribe.

Not aware of the existence of the malady on the European Continent, he designated it by one of its chief symptoms, he also mentioned that the Arabs had long been acquainted with it, that it appeared in a serious form every fifteen or twenty years, and that one of these crises, the one to which he was a witness in 1847, destroyed six hundred horses. The disease has continued in Algeria.

General Dumas, author of the "Chevaux du Sahara," alludes to the frequency and ravages of the disease among the horses of the tribes in the province of Constantine; and Bonjol, another Army Veterinary Surgeon, reports it as causing great havoc in the Bhiras tribe. In 1852, it carried off a large number of mares in the circle of Bou-Arreridj, and in 1853, it prevailed in the circle of Setif.

It was not until the spring of 1851 that it revealed itself in France, among the brood mares in the plain of Tarbes, where it for the first time attracted the attention of French Veterinary Surgeons, being chiefly studied by Roturior and Louchard, Military Veterinary Surgeons, and by an official commission. In 1851, the malady was located in thirty-one communes around Tarbes,

containing 1,874 mares. In December of that year, Louchard recognized it in 127 mares which had been put to Government stallions, and to stallions belonging to private individuals. The first had covered 750 mares, and 100 became diseased; the other 27 were infected by private stallions. Out of the total number 52 died. It had nearly ceased in the following year.

In 1852, the disease appeared in the Valley of Lourdes, and near Argeles; and Professor Yvart and Lafosse, of the Veterinary School of Toulouse, undertook, by a series of experiments, to demonstrate its contagiousness.

It re-appeared in some mares and stallions at Tarbes in 1856, 1857 and 1858, and at this period it was studied by Reynal, Director of the Alfort Veterinary School. It also manifested itself again in 1861.

With regard to the origin of this disease in France, Trelut, Veterinary Surgeon to the Stallion Depôt at Tarbes, in two able memoirs on the subject, traces its advent to the importation of a stallion from Syria in 1851, and again by two other stallions from the same country in 1861. He asserts that it was perhaps perpetuated in the South of France, because it there found itself in a climate resembling that of Syria, where it nearly always prevails; and also because no steps were taken to eradicate it thoroughly.

The disease has been carefully studied in France by St. Cyr. Trasbot, Laquerrierre, Beuise, and Nocard.

From time to time, Dourine is imported into the Basses Pyrenees by mares which have passed the summer in the mountains in the pastures and which have been covered by infected Spanish stallions. According to Schneider and Buffard it appears on the Spanish frontier every year.

In 1875 to 1881, Dourine was found in the Hungarian stud and was studied by Professor Von Thanhoffor of Budapest and it has recently been prevalent in Austria and parts of Germany.

An outbreak occurred in the De Wett country of Illinois in 1882 but its true nature was not recognized until 1886, and it is reported to have made great ravages.

The disease was recognized by Dr. W. L. Williams in Illinois in 1886.

In 1892 there was an outbreak among the breeding horses in North-Western Nebraska and it again appeared there in 1899.

In 1901 the infection re-appeared with increased vigour, this time in the Pine Ridge and Rosebud Indian Reservations in South Dakota where its eradication was extremely difficult, owing to the wildness of the country as well as of the horses and the fact that many horse owners would try to conceal them from the Inspectors.

In 1903 it was reported in the Van Buren County, Iowa.

Another outbreak was discovered in Taylor County, Iowa, in 1911. The diseased animals together with all exposed stallions were quarantined by the State and the disease eradicated.

In July, 1912, it appeared in Eastern Montana, the outbreak being more extensive than any of the previous ones involving the two Indian reservations in North Dakota and South Dakota and a force of 12 Federal Veterinarians assisted by State representatives were at work on the disease which was well in hand in 1914.

At the present time it occurs in Europe, in Spain (particularly in Navarre), and to a less extent in Hungary and South Russia ; also in Turkey which imports many horses from infected districts, also in Rumania where it has recently been studied by Marek, also in Germany.

According to Laveran and Mesnil the disease exists along the whole south littoral of the Mediterranean Sea, in Morocco, Algeria, Tunis, Tripoli, Syria, and probably throughout Asia Minor and in Persia.

It occurs in India and in Java where it was described by De Does as occurring in the Government Studs at Soemedang.

It was also discovered in 1904 at Lethbridge in Canada, has since prevailed in certain districts of Southern Alberta and in one locality in South-Western Saskatchewan, and its true nature

has been demonstrated there by Dr. Watson, after having been first discovered in 1904 by Chief Veterinary Officer, Burnett, at Lethbridge.

In India no reliable history is available, but from enquiries made from breeders and from the information gained by consulting available records, it may be concluded that it has been present in the country for many years. Such of the earlier records of the Horse-breeding Department, as are available, contain records of cases which were obviously Dourine, and year by year stallions were destroyed which presented marked symptoms of the disease. Indeed in the year 1885-1886 it was recorded in the casualty list of the Annual Administration Report of the Horse-breeding Department that No. 1628 Badminton H. B. E. died from "Mal de Coit." This is the first recorded diagnosis of the disease to be found in the records and it seems extraordinary that its contagious nature was not recognized and that it did not seem to have attracted any attention whatever. Long before this time, and ever since, cases of chronic disease of the sheath and penis, paraplegia, loin disease and the like, which were most probably Dourine, have been recorded in casualty lists.

Judging from such history of the subject as is available, it is very probable that Dourine was introduced into the studs many years ago by foreign stallions, and that it was the cause of many of the recorded cases of "Kumri" or paraplegia among breeding stock.

It continued up to the year 1904 owing to the use of infected stallions and mares in certain districts in the United Provinces, especially Bulandshahr, Aligarh, Agra and Muttra, part of Gurgaon and those parts of the Meerut District near the old stud at Hapur. It does not appear to be an indigenous disease in the Punjab, Baluchistan or Bombay, but it has from time to time been carried to districts or stands in these provinces by the transfer of diseased stallions to them from infected areas in the United Provinces. The true nature and method of spread of the disease in India was not suspected until 1902, and the fact that it is a contagious malady spread by Coitus was not generally recognized. Fortunately,

however, a stallion was generally thrown out of work when the symptoms were marked and hence it was not spread so rapidly as would otherwise have been the case. The unfortunate thing has been that a certain number of infected stallions remained at work and mares affected were not dealt with so that the malady continued to spread and consequently the losses from deaths and sterility have been very considerable indeed.

When the disease was definitely diagnosed in 1902, and its true nature and importance realized, it was found that many stallions had for some time been suffering in various parts of India and that some districts had long been badly infected.

Twenty stallions had been destroyed for Dourine from 1899 to 1901. In 1902 to 1904 fifty-seven Government stallions as well as a number of private animals both horses and mares were found suffering and destroyed.

In addition to these a number of infected stallions have been castrated and sold by auction. No records of the disease amongst mares and stallions, the property of private owners, are available.

The stands in the Bulandshahr and Meerut Districts near the Hapur Stallion Depôt at Babugarh have been constantly infected for many years and considerable numbers of stallions have been lost at Cherawak in Bulandshahr. The reason for this is that when a horse had been attacked and had come into fair condition again, he was often sent to the nearest stand to the depôt so that he might be easily inspected and kept under observation. Such stands, therefore, received a constant supply of infected horses and many mares in the neighbourhood became diseased in consequence. It was from such stands too that infected animals were sent to other districts for change of climate. It was a common practice to send an ailing stallion from a damp to a dry climate, in order that he might benefit from the change of air and undoubtedly the disease was spread in the Punjab and Dera Ghazi Khan District in this way.

As to the priority of diagnosis in India as above stated the occurrence of Dourine was recorded in the reports of the Horse-

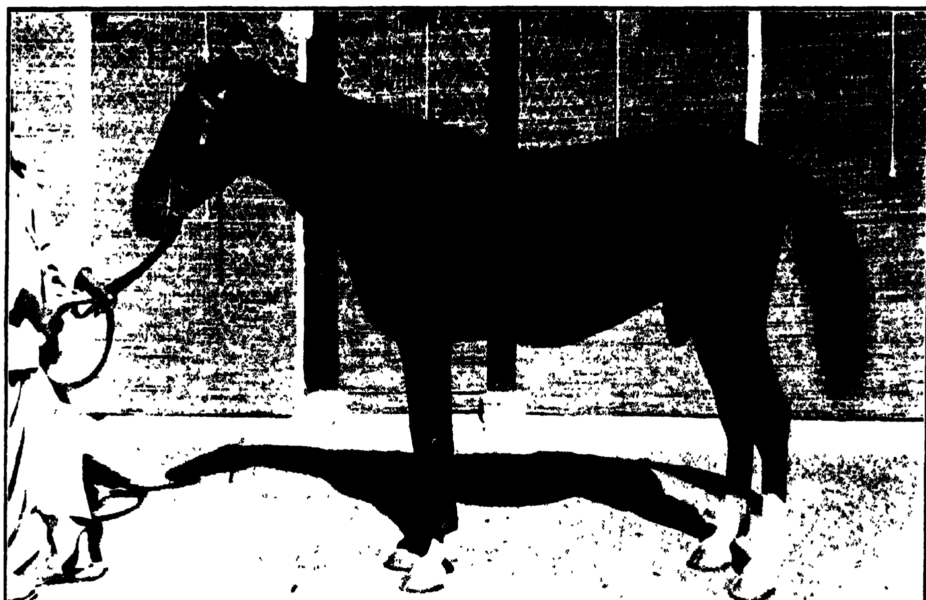
breeding Department in 1885. Lingard claims that certain symptoms exhibited by a country-bred mare pointed to the fact that she might be the subject of covering disease and that in July 1901, he recognized a case in an Arab stallion, but he did not confirm the diagnosis nor did he demonstrate the causal parasite. It is significant, however, that at this time a considerable number of cases existed among the stallions belonging to the Horse-breeding Department and nothing was said of the importance of dealing vigorously with the disease.

As a matter of fact it was not until we had definitely diagnosed it in stallions at the Punjab Veterinary College, had demonstrated the presence of the trypanosome and had experimentally transmitted it by Coitus and inoculation, that there was any certainty as to the existence of the malady in India.

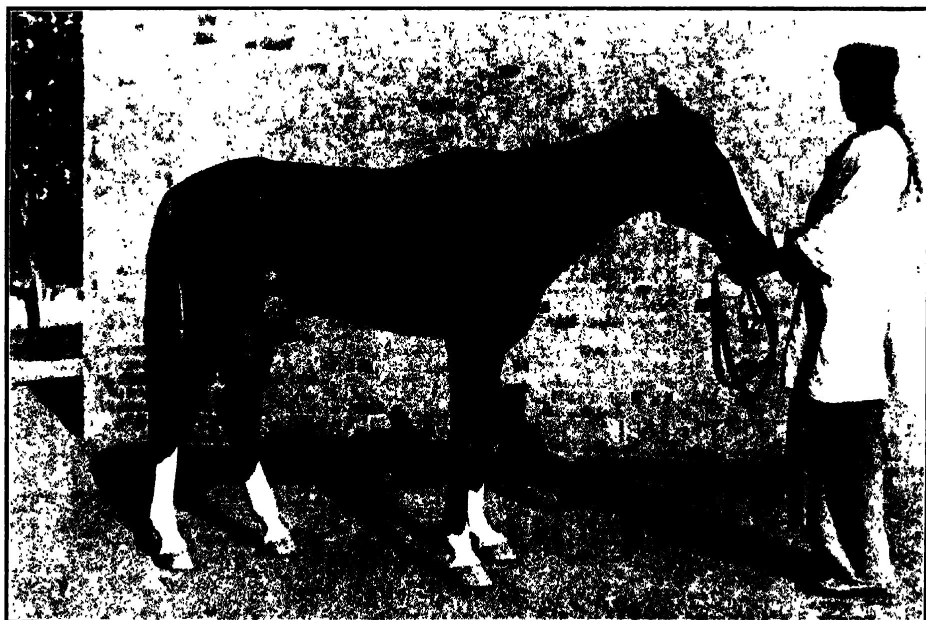
The report submitted to the Government of India in 1902, drew attention to the great importance of the subject (1) as it seriously affects the horse-breeding industry, being contagious, and leading to numerous deaths and to sterility both in the mares and stallions, (2) as it is very difficult to detect and diagnose, especially in the early and late stages, (3) because it is very insidious in its attack and usually chronic in its course, the affected animals being capable of themselves infecting others although at times showing no distinctive symptoms.

In the year 1903 I was deputed by the Government of India to ascertain to what extent Dourine existed and to suggest measures for dealing with it. An extensive tour in the districts known to be infected was made and as the result of the measures taken it was stamped out in those districts. All infected stallions were destroyed and no case again occurred in them until 1915 when a few cases were detected on the borders of Baluchistan in the Dera Ghazi Khan District.

At the same time it came to light that Dourine had become wide-spread in Baluchistan and eight or nine Government stallions had been attacked, some of them continuing to serve for a long time before it was suspected, and consequently many mares must



A recent case of Dourine with swelling of penis and œdema under belly.



A very bad case of Dourine.

have been infected by them. It is unfortunate that Baluchistan was reported not to be an infected district and was not visited in 1902.

Symptoms of Dourine.

Some authors adopt an arbitrary division of the symptoms of this disease into three phases, *i.e.*, œdematous, eruptive and paralytic.

In animals that are carefully watched from the beginning in India, no doubt in the great majority of cases the disease does evolve in this manner in imported horses, but it must not be thought that when one stage appears the others disappear or that all are present at the same time, nor must it be understood that in every case all the symptoms are marked.

From what follows it will be evident that only one symptom can be insisted on and that is the recurring œdema at the seat of inoculation or infection.

It must be observed that in dividing the course of this disease into periods the appearance of the important symptoms does not always follow in definite sequence, nor need one set of symptoms disappear before the others appear. In regard to the course which the disease will run, so much depends on the virulence and number of the trypanosomes introduced, and on the susceptibility or otherwise of the animals. A very great deal also depends on the acuteness of the observer, the opportunities he has of watching the cases, and the experience he has had of the malady.

The disease is most insidious in its attack in some cases and the symptoms may be so slight as to easily escape observation, and no definite course can be laid down.

In spite of all this I think that we may profitably divide the symptoms exhibited in the course of Dourine into those referable to the generative organs, the lymphatics, the skin and to the nervous system and may, for the sake of convenience of description, divide them into :—

(1) Changes in the genital organs and structures in close apposition.

(2) Cutaneous lesions.

(3) Lesions of the central nervous system.

In carefully observed cases in India they generally follow this order, but it is obvious that in some cases (2) may appear without (1) having been discovered owing to no marked external swelling having taken place, and (3) may be the first symptom seen, the other two having escaped notice. It is quite a common thing especially in Indian country-bred horses for the symptoms of (3) to be slight or not noticed.

This appears to be the case in other countries as well. It is only in the severe cases that paralysis occurs as a rule.

Watson writing of the disease as it occurs in Canada makes the following remarks.

In Canada the regular evolution of the disease has been the exception rather than the rule, and he thinks that the following notes may serve to put the diagnostician on guard.

" In the case of a mare, a stabled animal, and, therefore, under daily observation, the first visible signs of disease were symptoms originating from the central nervous system, which belong, according to the arbitrary division to the 'third' stage. These indications were followed by the first stage, namely, tumefaction of the genitalia, sexual excitement, etc. The first appearance of symptoms belonging to the second stage, namely, patchy infiltrations of the skin, the so-called plaques, were concurrent with the nervous manifestations and have later appeared when only a trace of the 'first' and 'third' stages remains.

In the case of an experimental animal the disease ran an acute course terminating fatally 139 days after infection. Nervous symptoms predominated throughout the infection.

In the case of another experimental animal, Dourine parasites were present in the vaginal mucus, at irregular intervals, from the 85th to the 229th day after infection and yet, only at the end of this period, have there appeared any visible signs of disease, these being more or less indefinite and limited to a slight tumefaction of the vulva and a somewhat swollen, anæmic, vaginal mucous membrane.

These may be extreme cases, but others can be cited. It is only necessary to emphasize the fact that in Canadian Dourine symptoms may appear shortly after or not for a very long period following infection, or that they may abate or disappear for equally long periods at any stage of the disease, and lastly, that loss of co-ordinate locomotion or other signs of nervous derangement may be the first and only signs of the disease detected."

This is generally in accord with the recorded views of European observers. Reynal states that the swelling of the sheath and enlarged inguinal glands may remain the only symptoms visible for a long time. This authority states that it may remain for 8, 10, or 12 months. But patches may appear during any of this time. Nocard and Leclaniche say that in some animals the evolution of the disease appears to stop for a considerable time, especially in young and well conditioned animals which are rested and well fed. Fleming states that in young, vigorous well kept horses the malady may continue localized for a very considerable time.

Schneider and Buffard speaking of the Algerian type state that they are led to the conclusion that symptoms may actually disappear and remain absent for a considerable time and re-appear again.

My own observations in India tend to confirm this in chronic cases.

Maresch has remarked that the examination of a horse in the paralytic stage may then show only the paralytic symptoms, and that the re-appearance of patches or œdema afterwards will lead to the supposition that they are secondary and not a primary symptom whereas they really are primary. In the second case quoted, although paralysis was the most prominent symptom others were apparently present.

In the third case the symptoms appeared in the right order although delayed.

In regard to the symptoms of the disease as it appears in India we have noted no wide divergence from those described by Schneider and Buffard as occurring in Algerian Dourine. These have been found to correspond closely with those observed in the horse in this country with the exception that the trypanosome appears to have

had its virulence considerably modified so that the disease produced is somewhat less acute and the number of recoveries greater. In carefully observed experimental cases it has been found that the evolution of the disease in the stallion generally commences in naturally acquired cases by changes which are limited to the genital organs.

(*To be continued.*)

TRAINING IN FIELD OBSERVATION.*

BY

W. BURNS, D.Sc.,

Economic Botanist, Bombay.

Efficiency is the watchword of all progressive men and nations. These men and nations get things done, they produce maximum results by their directed and controlled energies. The man whose vitality is high finds his greatest pleasure in the amount and quality of the work he turns out. The man of low vitality wastes what little energy he has, by the slipshodness of his methods, and finds no pleasure in his existence.

Personal efficiency depends on the training of every faculty to its highest usefulness. Of all faculties, that of observation is the most generally and most continually applicable by all workers. It has been proved that in the evolution of plants and animals those forms are ultimately successful which perceive most accurately and react most purposefully to their environment. With man, too, the successful individual is he who knows how to make all circumstances serve his purpose and to adapt himself to all circumstances. The ability, therefore, to perceive what goes on around one is a faculty of great biological significance, and it is no less a faculty of great immediate profit. After all, a man's pay depends on his value to his employer, and such value is multiplied many times in a man whose keen observation detects and turns to profit every point in the matters under his charge.

In scientific research the power of exact observation is essential, so much so that the development of this faculty may be said to

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constitute the first aim of any training in science. In India, science is now taught in many schools and colleges, and the importance of observation is insisted on in word but not in action. There is no doubt that with a certain syllabus to get through in a given time the tendency is to point out to the student all that should be noted in a specimen or piece of apparatus, and leave to the student merely the description. The inevitable result is that at the end of his college career the student has a fair power of describing known objects, but is considerably perturbed when set to examine something entirely new. A student must be taught to observe to the point of trusting his own observation against anything else. This is the more necessary when dealing with men whose ancestry and early training tend to develop reliance on authority and trust in memory. The following is a not uncommon example from the writer's experience: a student learns what sclerenchyma (woody fibre in plants) is, and its appearance under the microscope. He cuts a section of a new plant and (1) fails to see the sclerenchyma present in it or (2) sees it, but, not trusting his own observation, asks his teacher anxiously "Is this sclerenchyma?" If the teacher has common sense, he will answer, "Well, *is* it? Tell *me* that. You know what sclerenchyma is like and where it may be expected. Does this tissue show such characters and such position? If so, then say bluntly that it *is* sclerenchyma, and stick to your opinion." It is not uncommon for a student to state that he cannot see through his microscope. Casual examination reveals a thumb-mark on the eyepiece and a drop of water on the objective, but the student had not observed these, though warned to do so. Such are some of the early difficulties encountered when training men in observation work in the laboratory. Similar difficulties are encountered in the field. Men who are being trained in agriculture, geology, botany, entomology and certain other sciences require to do a good deal of observation work out of doors, *i.e.*, field observation. There is a difference between observation in the laboratory and observation in the field. In the laboratory, the worker sits down to study with concentrated attention some single object or set of objects. In the field the eye of the observer takes in a multitude of objects more or

less relevant to his work. He may have to collect information regarding the condition of a standing crop, study the distribution of weeds on waste ground, note the lie of the land and the probabilities of occurrence of subsoil water, or any such similar task. His brain must be sensitive to all impressions received and his eye must be a faithful servant in omitting nothing visible. The value or otherwise of a tour is dependent on the observation exercised during it. The writer is acquainted with a man whose admirable habit it is, when travelling by rail through a new district, to sit with notebook and pencil in hand and jot down as he sees them the objects of agricultural interest that appear. He interpolates the names of stations and the times of arrival thereat. In this way, at the end of his journey, instead of reporting vaguely that the land was fertile, he knows the actual crops grown and their distribution.

The members of various grades of the Agricultural Department in India have frequently to give opinions on land or crops, or diagnose plant diseases and their cause. Such opinion or diagnosis can be sound only if the observations made are extensive, searching and original. An error of observation or judgment may mean waste of funds, and loss of reputation. Some men feel that for the sake of that reputation something must be said whether fully warranted or not by their observations. They fear that the unlettered peasant or the educated though non-agricultural landowner may think them poor experts. Let it be so. The only possible line is honesty. If the observations give no information one must proclaim one's ignorance, and devise experiments to get further observations and possibly the missing clue.

Any training in field observation must start from this, that every point is to be noted but no conclusions drawn that are not absolutely warranted by the things seen. This brings up another important point, namely, that the eye is apt to see what it desires to see. When out buck-shooting, the writer has occasionally seen buck where no such animal existed. It is quite possible that Falstaff actually *saw* considerably more than two "men in Lincoln green" although his later imagination embellished the record of his terror-stricken eyes. Just as Pasteur tested first

the hypothesis to which he least inclined, so must the student be taught to see and register every fact, however contrary to what he expects, and even though it destroys the probability of a cherished theory.

As with observation in the laboratory, so with observation in the field, the training given has to counteract the effect of immersion in text-books and the unquestioning acceptance of statements on authority. Hence the necessity of leading students to see things for themselves as far as in them lies. For example the well-known "edge-effect" in a plot (*i.e.*, stronger growth of the plants near the edge), is a phenomenon which should not be pointed out. Students should be led to observe it for themselves. The observation may be guided by questions, but not otherwise. To begin with, a good deal of guidance is necessary, but gradually it can be reduced, and observation tests substituted, criticism being made on reports sent in. A student, for example, is given a palm grove for observation. He notes the presence of lichen on the stems of the palms, but omits to observe that the lichen is most on the north side of each trunk and practically absent on the south. He observes a dead palm, but omits to note the rubbish that indicates the presence of a boring beetle. The omissions are pointed out on the spot, and the man learns.

In the last resort, however, it is the man himself who must do his own education in field observation, and especially so when his period of studentship is ended and he sets out on his life work. Here success or failure awaits him, or perhaps that mediocre existence that is neither success nor failure. It is so easy to get slack, so easy to live below one's best, and retribution does not always follow quickly. One must keep the faculty of observation keen by use.

To sum up, the faculty of observation is essential to every man, and to none more so than the worker in agriculture or its allied occupations or sciences. Training in observation can and should commence from the earliest years, but too often these years are devoted to book work entirely and the mind is dazed and drugged. It is hoped that nature study courses in schools, taught by competent and observant teachers, will help to remedy this defect.

In later years, training in observation must aim at the development of the perceiving power, and confidence in one's own perceptions. Along with this should go education against seeing things desired and ignoring to things undesired, training in completeness of observation and finally and all the time absolute sincerity. To one who undergoes gladly the required self-discipline this training opens up a new world of power and enjoyment. Such an one lays hold on the universe.

RAINFALL, IRRIGATION, AND THE SUBSOIL WATER RESERVOIRS OF THE GANGETIC PLAIN IN THE UNITED PROVINCES OF AGRA AND OUDH.*

BY

E. A. MOLONY, I.C.S.,

Commissioner, Agra Division.

I. STATISTICS OF RAINFALL AND IRRIGATION FOR THE LAST TWENTY-NINE YEARS.

An examination of the statistics of rainfall and irrigation in the United Provinces for the last twenty-nine years reveals many features of interest.

Omitting the hill districts of the Kumaon Division the average rainfall of the cycle of nine wet years from 1886-87 to 1894-95 was 44·06 inches.

This cycle of wet years has been succeeded by two dry cycles, each of ten years duration, in the first of which the average rainfall was 37·33 inches and in the second 34·49.

The following table shows in acres the average areas irrigated during the same three periods :—

Cycle	From wells	From canals	From tanks and other sources	Total irrigated area
Wet cycle	3,898,746	1,345,396	2,813,337	8,057,479
1st dry cycle	5,293,490	1,900,037	2,501,084	9,694,611
2nd dry cycle	5,921,314	2,299,310	1,991,204	10,211,828

In considering these remarkable figures it is necessary to bear in mind that the area irrigated from tanks though considerable

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in ordinary years owing to the cheapness of this kind of irrigation always shrinks greatly during years of drought owing to the tanks failing to fill.

Irrigation from wells, on the other hand, shrinks in years of good rainfall because of the labour and expense of lifting water.

It was, therefore, only to be expected that the area irrigated from tanks would be greater and the area irrigated from wells and canals less in the cycle of wet years than in the cycles of dry years through which the Province has recently passed.

The increase in well irrigation is 52 per cent, in canal irrigation 72 per cent, while the decrease in tank irrigation amounts to 29 per cent.

It is clear that these differences are too great to be explained entirely by variations in the rainfall. The increase in the area irrigated from canals is due partly to new canals tapping new sources of supply, and, partly to the more economical distribution of water on the old canals.

The increase in the area irrigated from wells is due to the very considerable activity displayed for a good many years past in constructing new wells and in improving existing wells by boring.

II. The Subsoil Water Reservoirs.

The fact that nearly 58 per cent of the total irrigation in these provinces is from wells, coupled with the very general complaint heard of late years that the water level in the subsoil shows a serious fall, is an indication of the desirability of examining the problem of the underground water supply in order to ascertain whether it can stand permanently the existing drain on it, to say nothing of the much greater drain which the vigorous construction of wells, the systematic boring of existing wells, the sinking of modern tube wells of large diameter, and the introduction of mechanical power for lifting water are likely to impose.

We may assume that the following statements are either axiomatic or capable of easy proof :—

(1) that the level of the subsoil water is highest at a distance from and lowest close to the great rivers, which act

as main drains carrying away the water from the subsoil ;

(2) that the water in the subsoil flows very slowly but surely towards the great rivers ;

(3) that the difference in level between the subsoil water in any two places is due to the resistance offered by the subsoil to the flow of water from the place where the water level is higher to the place where it is lower ;

(4) that the faster the water flows the greater is the resistance, and, consequently, the greater is the difference of level of the subsoil water necessary to overcome that resistance ;

(5) from this it follows that the greater the flow of water in the subsoil the higher will be the level of the subsoil water at a distance from the great rivers and *vice versâ.*

To determine whether the subsoil water is likely to rise or to fall we have to determine whether flow of water through the subsoil towards the great rivers is increasing or decreasing.

This flow must depend on the amount entering the subsoil and the amount taken from it.

The amount which enters the subsoil is derived from (1) the percolation of rain water, and (2) the percolation of canal water ; whereas the amount that is taken from it is proportionate to the area which is irrigated from wells.

Canal irrigation and well irrigation therefore tend to affect the level of the subsoil water in opposite directions, whereas irrigation from tanks probably has very little effect either way.

The irrigation statistics above quoted show that the well irrigated area has risen by over 2 million acres and the canal-irrigated area by rather less than 1 million (954,000).

But of this 954,000 acres only 111,000 acres are irrigated from canals drawing water from rivers previously untapped.

The remainder is due to more perfect utilization of the old sources of supply and the better distribution of the water.

The more economical distribution of water means that less water per acre succeeds in percolating into the subsoil reservoirs, so that it is doubtful whether the increase in the area irrigated from canals during the last twenty years has made any addition to the water supplied to the subsoil by percolation from canals.

A comparison of the figures of well irrigation now and twenty years ago shows that there has been imposed on the subsoil water supply an additional drain amounting to the water necessary for the annual irrigation of two million acres.

On the whole, therefore, it seems clear, leaving out of account variations in the rainfall, that the annual net addition to the subsoil water supply is now considerably less than it was twenty years ago.

It follows therefore from the fifth assumption made above that there must be a less steep gradient in the subsoil water now than twenty years ago, and that there is a permanent tendency towards a fall in the subsoil water level.

If well irrigation continues to extend, it seems clear that the fall in the subsoil water level must continue. Doubtless in years of good rainfall the fall will be arrested, but the relief will only be of a temporary nature.

The question immediately forces itself on our attention whether there is any limit to the fall in the subsoil water level. The answer is that there is a limit.

It is known that the amount of rainfall which percolates into the subsoil is more than sufficient to supply water to all the land requiring irrigation. Therefore there is always some, though perhaps a very small, surplus which flows through the subsoil into the great rivers. Consequently the subsoil water can never fall quite to the level of the water in the great rivers, and our great rivers will never run absolutely dry even in years of drought.

It is however but poor comfort to the agriculturist whose well is already almost dry to tell him that the water level is not likely to sink more than 10 feet below the bottom of his well. What he wants is that we should raise the water level, or at least keep it from sinking any further. Therefore we should be well advised to make at once a thorough inquiry into the problem so as to

take any remedial measures possible before serious damage is done.

The only possible or desirable method of stopping the fall in the subsoil water level is to save as much as possible of that portion of the rain water or canal water which at present runs off into the rivers.

It is a very important fact at present very inadequately realized that the great natural reservoir for surplus rainfall is the subsoil and that all possible methods of getting the surplus rain water into the subsoil should be tried.

For many years past we have been busily engaged in trying to conduct the surplus water straight into the rivers by drains excavated at considerable expense.

With the much more economical distribution of canal water which is now practised the danger of water-logging the soil is much reduced; and it appears to be a matter for serious consideration whether the policy of surface drainage has not been carried too far.

The great fall in the area irrigated from tanks may possibly be due in some measure to this drainage.

The following measures are suggested as possible remedies or at least palliatives :—

(a) It might be arranged that at times when there was not a full demand for irrigation water the canals should utilize their surplus in filling tanks instead of running it to waste. Irrigation done from tanks so filled might possibly be charged at a lower rate so as to encourage villagers to get their tanks filled up.

(b) In undulating country an extension of the existing practice of constructing field or ravine embankments might do much to save water.

(c) Attempts might also be made to get a more direct and rapid flow of surface water into the subsoil by excavating sumps or wells in the beds of tanks or streams thereby making a direct communication between the surface water and the sand beds in the subsoil.

It is not impossible that drainage into the subsoil would be found to possess nearly all the advantages of surface drainage without its great drawbacks.

d) There remains lastly the keeping of all land under the plough. This would probably be the most efficacious method of all but the cost would of course be immense.

AGRICULTURAL SAYINGS OF THE UNITED PROVINCES.

BY

V. N. MEHTA, B.A., I.C.S.,

Officiating Deputy Commissioner, Bahraich, United Provinces.

(Continued from page 307, Vol. XI, Part III.)

II. AGRICULTURAL OPERATIONS, CROP DISEASES, ETC.

(a) *What and when to sow.*

Sow Kodon in Rohini, rice in Mrigshar, Jowar in Ardra—oh ye cultivator, follow this rule.

There are seventeen kinds of kuari and bhadain (early) rice in the District of Bahraich and neighbouring districts, *viz.*, Southa, Sauthia, Dhani, Kudia, Dudhi, Banspati, Parhani, Mutmuri, Talkand, Battisa, Anjana, Banki, Bagari, Ramkajara, Dihuli, Nokhwa, and Rambhog. It is best to sow early rice in Ardra, Mrigshar, and Punarvas ; and to sow transplanted rice in Pushya. Early rice sown later than Ardra gets weak. A lot of water is needed for their maturity. Sathi matures in sath or sixty days if it rains day and night. There must be wind from the west when the rice is getting into ear. It is said " If it rains from the south then where will you taste rice-gruel ? " It is also well known that paniya insect of rice is destroyed by western wind. A lot of water is required for rice either early or transplanted. It is said " Dhan pan (Betel leaves) and cucumbers are like water worms doting on water."

If a cultivator sows crops out of season, if he makes his threshing floor on low ground, neither the ryot reaps nor the Raja prospers and the substance all round is wasted.

Oh cultivator, sow sugarcane and Dihula rice. Don't sow anything save this. [The idea is that they yield a lot of produce.]

If you sow cotton and sugarcane then never mind if your house is near that of a usurer.

If rice is sown in Ardra you get grain, but if it is sown in Punarvas there will be a lot of chaff.

Sow Bajra (*Pennisetum typhoideum*) when Pushya (Pukh) comes. Then enjoy happiness according to your sweet will. (Do not sow Bajra in Ardra.)

Sow wheat in Chitra and rice in Ardra. The former does not suffer from rust and the latter from rainless heat.

Sow your rice during Pushya or Punarvas and cotton in Ardra. Sow Chana on niras or dry soil and linseed on wet soil. (Vide *Bulletin No. 53 of the Agricultural Research Institute, Pusa.* discussing agricultural ecology at the end.)

In the month of Pus do not sow seeds: grind them into flour and eat cakes thereof.

Do not sow kharif crops in Magha, eat your seeds.

In Chitra sow grain and in Swati barley.

If Kohi Amawasya (Pus Amawas is known by that name) is not in Mul Nakshatra and Akshay 3rd (3rd Bysakh Sudi) is not in Rohini, and Raksha-Bandhan is not in Sawan, then you waste your seed by sowing them.

(b) *How to plough, sow, irrigate, etc.*

Plough slowly, press your sugarcane juice quickly (drive the mill-bullocks fast), drive your bullocks drawing the leather bucket to a sweet paced walk.

If *you* work your well, in one day you will water 50 *kyaris* or crop beds. Sell your four ullocks and keep two good ones; after ploughing up let the patela (clod-crusher) be dragged n the clods.

The household in which the wife's brother is the charioteer, and the householder listens to the advice of his wife and spends Sawan not in ploughing the field, is ruined and he may as well beg for his bread.

There are many proverbs about the number of ploughings required to get a good crop.

Why is the wheat so flourishing? Because in Asharh there were two ploughings. Three ploughings in Asharh are as good as thirteen in Katik (for the *rabi* crop). [This is a reference to the hot weather ploughing and preparing the soil to retain the moisture that is precipitated during the rains.]

The deeper you plough the better will be the outturn. [This refers to deep ploughing and breaking up clods so as to admit of the formation of a deep root system able to catch moisture all round from subsoil water.]

Why was the crop so poor? Because there was poor ploughing in Asharh.

If Jowar (*Andropogon Sorghum*) is sown on soil newly broken for cultivation the outturn is considerable.

If you did not plough once in Asharh what is the good of ploughing often now? (The soil has become hardened, and moisture instead of being absorbed has run off.)

Plough the field ten times for wheat and twenty times for sugarcane.

If you break up the soil surface thirteen times, and water the crop beds thrice you get an excellent out-turn of sugarcane.

Cries out Jowari in a loud voice to the cultivator: "He who twists and turns me, to him I yield grain enough to break his mud jar. If any one respects me and touches me not, I yield him a shortage in seed even." [This refers to the process of scratching up the papri (surface crust) by running a harrow across in August to establish communication between subsoil air and atmospheric air and conserve moisture. This process is called Birai—Vide *Pusa Bulletin* No. 52 on Soil Ventilation.]

Crops say "If you put up ramparts round the field and dig up the surface ten times then take 10 maunds of grain per bigha." [This has reference to the provision of grass borders so as to prevent soil erosion. Vide *Bulletin No. 53 of the Agricultural Research Institute, Pusa.*]

Even Kiddies can plough in Asharh. (The soil is moist and without weeds.)

Regular ploughmen have to plough in Sawan and Bhadon. (Training is necessary.) But in Kuar (September-October) the ploughman must be the householder's son himself if good crops are expected. (This man should be both trained and assiduous.)

Plough a little, but move your patela (clod-crusher) often to break clods and make the surface even.

"Raise ramparts high round the field and if the crops are not good abuse the sooth-sayer Ghagha." The proverb refers to regions where the soil is not loamy. Loamy soil by Sarawan action becomes very packed and inhibits aeration.

The Mung (*Phaseolus radiatus*, Linn.) planted mixed with Jowari is shouting as she is grovelling on the ground to her taller sister Jowari, "Oh sister, lift me up too," and the Jowari says, "Plough me up or I yield no grain." Mung being leguminous wants room in order that its nitrogen factories can get sufficient air for optimum work.

Masur (*Lens esculenta*) and gram fields do not require much ploughing just as the left-handed offspring does not recognize obligation.

Sow your Sann (*Crotalaria juncea*) thick and close, your cotton far apart. (Sann should not spread out. Its long fibre is prized. Cotton must branch out in order that as many pods as possible may be borne.)

Sow your Jowari at such a distance as to be covered by a frog in one jump.

Sow your sugarcane in rows leaving distance of one pace in between.

Maize plants should be separated by a cubit.

Sow Dhan (paddy) on dumat (loamy) soil, Bajra on sandy soil, cotton on gauhan (highly manured land near a village site), and gram on khadar or the outlying land of the village.

Pakar tree (*Ficus infectoria*) should be grown on sandy ridges, Mothi (*Phaseolus aconitifolius*) along with Bajra.

Sugarcane must be sown on *Ravara*.

Sow your pulses after cleaning them the last during Magha. After that think of *rabi* sowings.

That is good cotton which is picked in Katik.

The wasps have taken shelter in vestibules, it is the time for sowing barley.

Then there are certain rhymes showing the interdependence of particular grain annuals on the prosperity or otherwise of the fruit-bearing perennials.

If the Aka (*Calotropis gigantea*) is prosperous then Kodon (*Paspalum scrobiculatum*) should be extensively sown; if Nim (*Melia azadirachta*) is prosperous barley should be preferred for sowing; if thatching grass is luxuriant, wheat should be sown extensively; do the same with gram if the Ber tree (*Zizyphus jujuba*) bears many fruits; look at the Karela plant (*Momordica Charantia*) and if the fruit is plentiful then put extensive area under cotton.

If the mango crop is good then Jowar will also be good; a good crop of Mahua (*Bassia latifolia*) foretells similarly about barley.

(c) *Manuring is strongly advocated.*

That is a field in the proper sense of the term on which manure has been spread out, otherwise it is mere rubbish and sand. If you do not manure, the field will remain sandy like a river bed.

Manure liberally in Asharh and gather corn at your sweet will thereafter.

Put cowdung, poudrette and the Nim Khali (nim cake) as manure and you will get double the average out-turn.

If you manure your field with cowdung, ashes, and rotten leaves the ears will bear substantial grain.

"You cannot do what fate has not ordained you to do. But if you manure the field you are bound to get good crops." This is poet Rahman's saying.

If the cultivator manures his field well, he can store 100 maunds of grain in his earthen jar.

If you manure kurahal land (land ploughed up in the hot weather in order to sow rice) you will see well-filled ears bearing a lot of corn.

He is a past master in the art of cultivation who spreads bone-powder in his field.

If you manure the fields with cowdung, and leaves of Chakwar and Arusa (*Adhatoda vasica*) you will get almost the major portion of the weight in seed and very little in chaff.

Sow Sanai (*Crotalaria juncea*), cut the Sanai, then plough it up, up and down, in the whole of the field and you will see proportional rise in the weight of grain. (Vide *Pusa Bulletin* No. 56 on Green Manuring, by Mr. Dobbs.)

If the cultivator has no manure then he is really miserable.

If you do not see manure in a field infer that the cultivator is without means.

(*d*) *Plant diseases and pests, etc.*

Avoid circumstances that bring about the advent of Lohai (insect pest) on sugarcane. That would ruin the crop.

The unfortunate cultivator's crops suffer either from frost or hail.

Ghagha declares that if there is moisture in the subsoil and clouds above, then wheat will suffer from rust.

East winds in Phagun bring about rust. If it rains in Chitra the soil deteriorates and renders the crop susceptible to rust.

If gram fields get wet and the weather is cloudy then the crop will be eaten by Gadhela insect. East winds usher in weather conditions like the above.

If you thresh your corn when the west winds are blowing your grain will not suffer from Ghoon insects (weevils), [*See* Mr. Moreland's "Agriculture in the United Provinces," page 117]. If east winds blow in Pus and Magh, the Mauhun or aphis eats up Sarson plants.

Frost strikes down crops lying on a slope. (Crops on a slope cannot take enough water. Frost kills them first.)

Bugs breed in Magha and cattle-flies in Purva but in Uttra all these insects are killed out.

III. General.

Oh cultivator, if you exert a little bit yourself you will do a lot for the State.

Cultivate to the extent of your means—otherwise if you lose in cultivation your house and manure heap will all be sold away.

Cultivation is the best profession, money-lending is middling, service is still worse and after that comes begging.

The fact that agriculture requires the close personal supervision of the farmer himself and even ploughing with his own hands is well brought out in the following:—

If you yourself cultivate then it is called cultivation. Else you might as well leave everything fallow.

His is the cultivation who handles the plough himself. It is half his if he merely supervises.

If any cultivator has to ask where his plough is (leaves to another to do the work) he might as well sell his bullocks.

Even though accompanied by a lakh of men who are at your beck and call, it is best if you look to your cultivation as well as to the saddle straps of your horse yourself.

If while you are a cultivator you are keen on getting interest on money-lending, then you reap profits neither in the one nor the other.

If you sleep in Asharh you will weep in Katik.

Just as seeds are thrown in so will the fruits be.

What is written in fate cannot become otherwise.

Lucky is the owner of rice that falls down.

Unlucky is the cultivator whose wheat falls down.

The highest and most appropriate valuation of the cultivator's attachment to the soil is in the present writer's opinion given in the following couplet of Tulsidas and I accordingly end this collection with his quotation:—

Tulsi Ramahin yon bhajyo jeon kisan ki riti.
Dam chauguno rin ghano tohun khot se priti.

"Just as the ideal devotee Tulsidas is devoted to his love 'Rama' so is the cultivator to his land: let the cost grow fourfold and debts accumulate and yet he ceases not to love his field."

New rhymes are being coined every day. This tendency is inherent in human nature to begem its priceless experience in an appropriate rhyme. The present writer heard a cultivator compare indigo to the dancing girl's daughter and cotton to her son. The one made for excellent rabi and brought in wealth, the other was showy but rendered manuring necessary for rabi and was expensive. The other day I read in an extract from the Jullundhar Settlement Report a proverb coined in the twentieth century, "Ploughing with Rajah's plough, sowing with Pusa 12 wheat, and using chain harrow bring the wealth of the kingdom (to the cultivator)." It shows the tendency still at work of begemming dearly purchased experience in rhyme. The age of Sutrakaras is not gone.

Selected Articles.

NON-CO-OPERATIVE AGRICULTURAL BANKS
versus
CO-OPERATIVE CREDIT INSTITUTIONS.*

BY

PROF. J. C. COYAJEE, M.A.

IN the first number of the *Indian Journal of Economics* an article has appeared, from the able pen of the Hon'ble Mr. D. E. Wacha, advocating the establishment of agricultural banks with a certain amount of state assistance, and asserting that they alone can solve the problem of agricultural indebtedness. The writer's conviction is that no possible " number of credit co-operative societies of the character now instituted .... would be of any avail if it really be our aim and object, once for all, to relieve agricultural indebtedness." As a signal proof of agricultural banks to wipe out agricultural indebtedness the history of the agricultural bank of Egypt is narrated and is mainly relied on. Pronouncements coming from such a veteran publicist as Mr. Wacha deserve to be respectfully and soberly considered and to be widely discussed.

Mr. Wacha observes in one place that it is not the object of his paper to criticize the merits and demerits, whatever they may be of the " new-fangled " co-operative societies. But evidently he holds them in small respect and prophesies boldly that " Their

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* Reprinted from the *Bengal Co-operative Journal*, vol. II, no. 1, July, 1916.

constitution, the method and manner of their working, and the new control and grip which the Government are going to have over them, all these must eventually toll their death-knell." According to him the same fate that has befallen the *takavi* advances and the efforts to relieve the Deccan agriculturist is bound to overtake the agricultural credit societies.

In order to make up one's mind about Mr. Wacha's proposal one has to consider whether the history of agricultural banks shows that they alone can so materially reduce agricultural indebtedness as to make co-operative banks superfluous. One must inquire further into the measure of success achieved by the Egyptian Bank and into the degree of resemblance between the Egyptian project and Mr. Wacha's idea. It may also be asked whether co-operative unions and central banks may not perform the same work as the proposed agricultural banks. Any difficulties in the way of starting and working these banks may be then examined. Lastly, one should consider whether co-operation brings with it other economic, moral and political benefits which it would be unreasonable to expect from mere "agricultural banks."

A preliminary objection might be raised to the ideal put forward which is said to be "once and for all to relieve agricultural indebtedness." There is a rhythm pervading all economic affairs and no class can keep itself permanently out of debt — least of all the agricultural class with its liability to suffer from bad seasons and famines. The ideal set up is as practicable as the socialist ideal of equalization of property; the truth being that the moment after fortunes have been arbitrarily equalized the process tending towards inequality of property will start again. To say that all agricultural debts can be removed is only a little less fallacious than to say that all debts could be abolished. The debtors, like the poor, are a class which we shall always have with us.

Let us first study the lessons to be derived from the history of "agricultural banks." The case of Egypt, which Mr. Wacha has emphasized, will be dealt with a little later; but the history of agricultural banks is a long and instructive one, and not in any way confined to the small and late Egyptian experiment. A great

many countries in the world have possessed not only individual agricultural banks but whole systems of them, but nowhere have they either abolished all agricultural indebtedness or made co-operative credit institutions superfluous. A few examples will illustrate this statement. Germany possesses numerous agricultural banks. There are the Landschaften, *i.e.*, societies for lending money on farm mortgages which have earned high praise. Mr. Herrick (late Governor of Ohio and Ambassador to France) says of them : "The Prussian Landschafts are generally recognized as nearly perfect with reference to organization and administration, while it is also believed that if their business methods were modernized and made less cumbersome, they would be the best institutions in Europe for according long time credit on large or small farms."[1] Besides the Landschafts there is a long array of other agricultural banks. There are the land-credit banks which are institutions which aim at obtaining cheap money for all citizens who have good lands to offer as security. There are the land-improvement annuity banks to lend money for land improvement projects. Fourthly, there are the general commissions and rent charge banks with the object of lending money for creating homesteads for smal holders. Nor does this exhaust the classes of agricultural banks in Germany. The savings banks, the insurance institutions, and smaller land-credit banks offer these services to the agriculturist by buying up his mortgages. All these institutions cater for the agriculturists, and each class is adapted to the requirements of a different type of cultivators and to meet some of the special needs of the agricultural community. Yet has this formidable array of institutions wiped out agricultural debts or hindered the growth of co-operative institutions ? Far from it ; Germany has carried rural co-operative organization to the highest pitch, and there are more than 17,000 co-operative societies in that country. Professor Pope[2] tells us that "in Germany the greater part of the personal credit of the owners of small and medium sized farms is furnished by the Raiffeisen co-operative banks."

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[1] *Rural Credits* by M. T. Herrick, p. 225.

[2] Pope : "Agricultural Credit," *Q. J. E.* XXXVI. p. 728.

There is no intention here of denying the great services rendered to Germany and Austria by the "provincial banks" of these countries. But it should be noted, in the first place, that these banks are state-owned and do not aim at profits ; in the second place, they do not compete with co-operative institutions but merely *supplement* them. The co-operative banks furnish personal or short time credit, while the "provincial banks" grant mortgage credit or long time credit mostly for financing land reclamation or improvement projects.

France, too, has tried the experiment of agricultural banks for more than half a century. It has worked on a highly centralized system and has endowed the Crédit Foncier with important privileges including the powers of sequestration and expropriation. But this appreciation of agricultural banks has not prevented France from throwing itself vigorously into the movement for co-operative credit, and its experience in co-operation has furnished valuable lessons to the world. At first France tried its usual policy of centralization in the co-operative, but it proved a failure. "Since then decentralization has been recognized as the true principle, and the systems since formed for independent farmers capable of taking care of themselves have been constructed on the idea of *building up from the ground and creating credit facilities at the very door of the farm homes.*" Another authority—Mr. Morman—observes to the same effect : "Formerly the idea prevailed among French statesmen that agricultural credit could only be established by the formation of a great central bank from which credit would flow out to all the local credit centres. But when the Government of France finally took up in earnest the question of agricultural credit it was planned on an entirely different principle. It was decided that *rural credit should begin with the lowest group ; that the agricultural co-operative society should form its own credit bank which should grow up from its own activity.*"[1] (The italics are ours.) The second lesson which France has to teach is that lavish state-help is only a burden to a co-operative movement. There are two systems of co-operative credit banks in France—those receiving direct aid

[1] Morman, *Principles of Rural Credits*, p. 43.

from the Government and those working with their own capital—and, of the two, the latter class has proved far the more successful. As Mr. Herrick observes, "state-aid, which has been so lavishly extended in France, has registered a conspicuous failure." The salvation of the agricultural community is not to be achieved by outsiders.

Italy also has organized a system of excellent agricultural banks, yet it is there that Luzzatti originated a new type of people's bank, while Wollemborg implanted a new system of rural credits especially adapted to Italian conditions. Italy possesses more than 2,000 co-operative banks organized on the Raiffeisen system. In Austria-Hungary, in Russia, in Rumania, and indeed in all continental countries there exist both "agricultural" and co-operative banks—the latter a more recent and progressive growth in each case. Japanese conditions might well be of particular interest to India. Japan has no lack of agricultural banks—there is a central land-credit bank, besides 46 local banks and there are, besides, regional agricultural banks for Saghalien, Formosa, and Korea. This great growth of agricultural banks has not, however, enabled Japan to do without the modern co-operative societies. That country had, indeed, in the Hotoku-Sha an older form of co-operation. But since 1909 Japan has introduced co-operation of the European kind. In three years it had achieved wonderful progress, for in 1912 there were 9,349 co-operative societies with one million members and thirty federations. In Japan co-operative societies are of four classes—credit, purchase, production, and sale. The scale of their operations can be judged from the fact that the three sales-societies in the silk-producing areas had total sales amounting in 1914 to over 70,00,000 rupees. Prof. Hamilton observes that "there is sure to be a development of co-operation in Japan which will be of the highest interest to those who believe in co-operation for India and are striving to encourage its growth."

The whole history of agricultural banks thus shows that the demand for loans is much larger than can be met by non-co-operative agricultural banks. There is a limit to the influx of outside loan fund or floating capital which can be attracted into the field

of agriculture. There is a proportion naturally fixed—we may call it an equilibrium—between the capital employed in agriculture and the capital otherwise employed and it is not possible very greatly to increase the former at the expense of the latter. An excellent illustration of this is supplied by Prof. Pope, whom we quoted above, who remarks that "in Europe, despite the favouring conditions, the farm debenture bond finds a market with difficulty owing to the competition of other securities, *i.e.*, the agricultural banks cannot attract capital owing to the competition of industries". So also the Director of the Landschaft of Halle writes that "the development of industry has produced a condition whereby these bonds are not as generally acceptable as before ....At the present time, therefore, there is greater difficulty than before in placing the bonds." Thus we see that the supply of capital in the hands of agricultural banks falls very much short of the demand, and the wiping out of all agricultural indebtedness by these banks is quite out of the question.

We now come to consider the Egyptian experiment with an agricultural bank on which Mr. Wacha relies so much. Looking up the Administration Reports of Egypt and Sudan, we find that even the Egyptian officials and administrators claim only a moderate and modified measure of success for the Agricultural Bank of Egypt. Thus we read in the Report of 1902: "When I say that *a certain degree of success has been attained in Egypt,* I really mean that, under the new system, it is clear that the fellahin are anxious to borrow, and that arrangement for advances and recoveries has worked well. Before it can be said that the system has been completely successful, it has to be shown that the fellahin are not generally *making use of their improved credit to contract fresh debt* at ruinous rates of interest." (The italics are ours.) Complaints also appear in the Report of 1899 that "the 10 per cent. interest charged is too high a rate of interest to charge, as the fellahin can often obtain loans at that rate from the local money-lenders."

The system of lending by the Agricultural Bank of Egypt has also the disadvantage, noticed by Mr. Wolff, that "it precludes control of the borrowing, which in a country like Egypt is desirable

for the borrowers' own sake."[1] Some of the money lent without such control is no doubt wasted. It is only under the co-operative system of credit that a good part of the money borrowed by the fellahin is not likely to be put to non-productive uses. In his work called "La Situation Economique et financiere de l' Egypte," Prof. Arminjon of the Khedivial Law College asks: "For what then does all this enormous capital distributed by the Agricultural Bank of Egypt serve? Too often it is used for purposes of no advantage to agriculture, for example, for some festival, or to relieve a young man from doing military service." We read further on the same subject: "The financial Council of the Bank recognizes that the difficulty that the debtors experience in fulfilling their engagements depends, in too large a number of cases, upon the improvident use they make of the money lent. The practical conclusion from the observation would be only to grant loans on condition of their being invested in a remunerative manner. But it is evident that a bank cannot proceed to verify the use that 250,000 customers make of the capital they borrow. It is perhaps possible to find a solution in the constitution of co-operative credit societies to act as intermediaries between the Bank and the farmers; their guarantee would preserve the Bank from all risks of loss and, on the other hand, they would contribute to attain the end of not giving any loan which would not benefit the farmer. In fact M. Arminjon and many other competent persons observe, such an office might be perfectly discharged by the board of management of a co-operative society, the members of which while bound by their joint and several liability know one another and can control each other."[2]

But has the Agricultural Bank of Egypt succeeded in wiping off the debts of the fellahin? By no means. "By its own unaided efforts, certainly, the Agricultural Bank of Egypt cannot provide for the needs of all the peasant farmers, the number of whom is extraordinarily large." Irrefutable proof is given of the heavy rural indebtedness still existing in Egypt by no less an authority

[1] Wolff: *People's Banks*, p. 498.

[2] *Bulletin of Economic and Social Intelligence, Rome*: March, 1912, pp. 166-7.

than Lord Kitchener in the Report of the Finances and Administration of Egypt in 1913. He had wisely appointed a commission to compile an accurate return of the debts of the poor fellahin, and on the basis of that report he speaks of the "appalling weight of the debt to be borne by the poorest class of cultivators of the soil in the country." So much for the claim that "a beneficent change has come over the fellahin since the bank opened its doors."

Secondly, has the success of the Agricultural Bank of Egypt been such as to make co-operative credit institutions unnecessary ? The answer is again in the negative. As Mr. Wolff puts it, "the demand (for loans) has outgrown the capacity of supply of the Agricultural Bank." By 1910 the first co-operative society was founded in Egypt. Even in the absence of the legislation for facilitating the formation of such societies the movement has spread, and in 1912 there were nine co-operative societies. These beginnings of co-operation were appreciated by the greatest of Egyptian rulers—Lord Kitchener—who gave the movement his official benediction in the Administrative Report of 1913. He observed: "The possibility of successfully working such (co-operative) system in Egypt and *the advantages to be obtained by it have been demonstrated by experiments* in several villages throughout the country. The creation of a Ministry of Agriculture has greatly facilitated the development of village syndicates, as the new Ministry will be able to supervise and assist the agricultural operations which the co-operative societies will undertake in the villages. Undoubtedly the principal factor on which their success will depend will be the degree of facility with which they are able to obtain advances of money at cheap rates. Such rates can only be obtained by establishing syndicates on the legal basis of registered civil companies, and by placing their finances under the supervision of the Finance Ministry. As soon as legislation on these lines has been enacted, we may hope to see a *considerable development of the application of the co-operative principle* to agricultural life in the villages. The help thus afforded to the smaller cultivator will be of great value as soon as the direction of the village syndicates has been rendered thoroughly reliable both as regards its operation and its finances."

Indeed the official opinion in Egypt seems now to have veered round completely on the side of co-operative credit institutions. In his note on the Budget of 1913 the Egyptian Financial Adviser remarked: "The best guarantees for the proper limitation and employment of agricultural credit are those provided by the co-operative system"; and Lord Kitchener observed that he was "entirely in agreement with his adviser." *That after nearly twenty years of experiments with state-loans and agricultural banks, the Egyptian Government should decide so whole-heartedly in favour of co-operative banks is a signal triumph for the advocates of co-operation.*

But even had the Agricultural Bank of Egypt achieved far greater success, that would not have made out Mr. Wacha's case. The two schemes are widely different. Mr. Wacha wants Indian capitalists to take their courage in both hands and start provincial banks which are to be private enterprises. But "the Agricultural Bank of Egypt . . . . is supported and controlled by the State. About one-third of its shares are owned by the National Bank which stands in close relation with the Government."[1] This is not Mr. Wacha's aim who says in the spirit of a bold and self-reliant individualism, which does him great credit, "private enterprise alone is needed." Moreover, the Agricultural Bank of Egypt was founded by European capitalists, whereas Mr. Wacha relies on his provincial banks to work with local capital. Thus the two schemes are radically different, and no inference can be drawn from the fortunes of the one to the prospects of the other.

Coming to the next stage of our argument it may be urged that everything that is useful in the "agricultural bank" scheme is already to be found in the co-operative credit system, which, through its central and provincial banks, can draw what capital is necessary from outside sources. Moreover, the co-operative central banks (like the one at Bombay) can offer better security to the lender; for while the "agricultural banks" are only backed up by the proposed Government guarantee the co-operative central banks have not only a similar Government guarantee behind them but also the joint liability of the local banks and their members.

[1] Herrick: *Rural Credits*, p. 188.

A very good example of this is found in the co-operative system of Italy. In 1913 "the capital and reserves of the Italian co-operative banks totalled $600,000. The deposits amounted to about $20,000,000 most of which came from outsiders" (Herrick). In Prussia about a third of the money at the disposal of the co-operative banks is borrowed from non-members, and in India more than half the capital of the central co-operative banks is obtained thus. But the co-operative banks have got other resources. While utilizing outside funds so far as necessary, the co-operative system stimulates thrift and thus creates new capital which did not exist before. The "agricultural banks" can only *transfer* existing capital, but the co-operative banks *create* new capital by awakening the thrift of agricultural classes. If the saving power of the vast agricultural masses is not thus stimulated, it would need a vast transfer of non-agricultural capital to agricultural purposes in order to reduce sensibly the load of agricultural indebtedness. Since Egypt requires many millions even to make some impression on its debts, India will require many times larger sums to shake off its much larger incubus. The proposal for starting "agricultural banks" has besides been brought forward at a particularly unpropitious time. After the present war India will have to rely mainly on its own resources for its ordinary supply of capital and the amount of local capital will fall very far short even of the usual demand. To require it further to attack the stupendous problem of agricultural indebtedness seems to be a hopeless enterprise. How many millions, does any one think, can, for some years to come, be raised in India by an offer of a 3 per cent. guarantee ?

Those who talk of such a stupendous extension of banking in India as to take over in a few years all agricultural debts are underrating seriously the manifold difficulties in the way of the extension of banking. The history of banking shows that healthy financial development is necessarily slow. India has very recently had an experience of the results of too rapid a growth of banking. The capital and debenture bonds of the proposed agricultural banks would require many millions, not to speak of the great development of financial talent and business honesty needed for the safe progress

of such an enterprise. An unprecedented growth of banking ability and resources would thus be required from a backward and conservative country. It is only a heroic assumption that the *mahajans* would, on the formation of such banks, turn over all their capital to them. On the other hand, so far as possible, the local co-operative banks and unions are beginning the work of annexing both the *mahajan's* capital and local hoards. They have greater facilities for the task, as, naturally, local concerns and enterprises can attract local capital with greater facility than distant provincial enterprises.

Some of the difficulties in the way of non-co-operative agricultural banks may now be considered. Mr. Wacha proposes that Indian capitalists should start an agricultural bank in each province. To this it may be objected that the provincial banks so started will be too distant from the cultivators and will have great difficulty in judging whether particular cultivators or schemes deserve to be encouraged by grants of loans. Even co-operative banks have failed to produce the maximum good of which they are capable when they have assumed to deal with large districts, as has happened in Russia. Banks conducting operations in large districts cannot possess a proper knowledge of their clientele.

Difficulties will also be encountered by the agricultural banks owing to the number and complexity of the land tenures of India. In some parts of India the land virtually belongs to the cultivator, in other parts he is a mere tenant, in still other cases he is only one member of a large proprietary body. Thus the security for the loans of the agricultural banks will differ immensely in value, amounting in some cases to the whole value of the farm, in other cases to mere nothing, and the loan system will have to be administered in the midst of a wide variety of circumstances, while the system will not possess that adaptability to circumstances which co-operation can show.

And here a protest may be registered against Mr. Wacha's proposal to employ the tax-gatherer to collect the interest or the principal of the loans made by the agricultural banks. As Sir Frederick Nicholson says: "It would develop, in a high degree, the habit of attempting to overreach and defraud that entity vaguely

known as 'Government,' which is usually credited with unlimited means and with the ability to overlook individual debts; it would add the odium of bailiff to that of the tax-collector—*odio vectigali odium fenebre*." The State will not increase its popularity by constantly and increasingly appearing in the guise of a creditor. But, above all, for the tax-gatherer to be constantly liquidating the debts of cultivators under the threat of attachment is to place the agricultural community in a *quasi*-insolvent status annually and to declare it unfit for ever to manage its own business affairs. To be thus kept perpetually in *statu pupillari* is sure to have a degrading effect.

Besides helping to alleviate the burden of agricultural indebtedness, co-operative credit institutions offer important collateral advantages both to agriculture and industry which are entirely outside the range and programme of "agricultural banks." On these collateral benefits Mr. Herrick observes: "The only difference which can exist between the interest rates of a co-operative credit society and an ordinary bank comes from the economies effected in the former by not paying large salaries or sharing profits with outside stock-holders or third parties. . . . . . Besides the reduction of interest rate on loans resulting from the saving of expenses, it offers other advantages of a more important character by acting as the business head or financial centre of all activities in the neighbourhood. It either makes collective purchases and sales for members, as in the case of the Raiffeisen credit societies, and thus enables them to obtain supplies at wholesale prices and to dispose of their products without paying commissions to middlemen; or else, as in the case of French syndicalism, the credit association or its members form other associations connected with it for these purposes." He might have added that genuine co-operative banks possess a vital principle which alone could have brought about that wonderful adaptability to the very diverse local circumstances all over the world which co-operation has shown for several decades. It has also shown its power not only to help agriculturists but to serve the varied needs of many other classes. There are co-operative non-credit societies helping industry and trade in numerous ways.

There are, on the basis of co-operation, sale societies, insurance societies, irrigation societies, dairy societies, employees' societies, societies for mill-hands and other varieties almost innumerable. Surely the "agricultural banks" can never even aspire to serve all these classes and their needs.

Nor can agricultural banks bring with them that moral, educational and even political progress which has followed in the wake of co-operation. Its value as a teacher of morality is best seen from what happened in the case of Switzerland. "Necessity did not bring co-operative credit into being in Switzerland. It was started because of its moral effect in teaching farmers to be their own bankers and to be mutually responsible for one another." About its merits from the political point of view, His Excellency Lord Carmichael has observed : "In future these societies will take the place of the old village institutions which once existed in India, and I am sure I am right in thinking that if they do so, there will be a great change for the better in the administration of the country." So also such a distinguished administrator as the Hon'ble Mr. P. C. Lyon has remarked : "It is recognized now on all sides that a successful village society means a far step forward in education and local self-government ; in fact the resuscitation of village government in its most attractive form." These wise statesmen have discerned that decentralization and federation are the watchwords of the world-politics of the future, and that local, central and provincial co-operative societies afford excellent discipline on both lines. The body-politic like the healthy natural body should consist of healthy cells, and co-operative work serves as a tonic to the village-systems, which are the cells of which a country is composed.

It is hardly right to call co-operative societies "new-fangled societies." There is enough material, indeed, for a monograph on the antiquities of co-operative credit. In India forms of mutual credit and co-operation have existed for centuries. Russia had its artels and other forms of co-operation. The South-Slavs, especially the Croats, had such societies for ages past. Austria possessed co-operative dairies even in the Middle Ages. The annals

of Japan, Sweden and Switzerland show the same co-operative tendencies. Thus, the usage of centuries has shown the importance of co-operative.credit.

We may sum up our argument thus—the history of "agricultural banks" does not show either that they can wipe out agricultural indebtedness or make co-operative credit institutions superfluous. Secondly, Mr. Wacha's scheme is not on all fours with the Egyptian plan, and such success as the latter has attained cannot be cited in favour of the former. Indeed the Egyptian Government has itself been converted to the cult of co-operation. Thirdly, that provincial co-operative banks and unions are already working to secure the necessary outside capital for the agricultural class, and that the establishment of another set of provincial agricultural banks is superfluous. Fourthly, it is very doubtful whether under the present circumstances and in the absence of a stimulation of thrift through the spread of co-operation, an extension of banking can take place large enough to reduce sensibly the agricultural indebtedness in India. Lastly, "agricultural banks" lack the vital principle of co-operative banks, which renders the latter such excellent institutions for conferring economical, moral, educational and even political advantages. Non-co-operative agricultural banks may to a certain extent supplement, but they can never supplant, co-operative credit institutions.

THE RECENT DEVELOPMENT OF GERMAN AGRICULTURE.*

In a Parliamentary Paper† which has recently been issued by the Board of Agriculture and Fisheries an account is given of the recent development of German agriculture. The memorandum covers 74 pages, and represents an attempt to explain why it is that in recent years German agriculture has made such a rapid advance, while in England the production of food from the soil has decreased. It is prefaced by the following note, dated 1st June, 1916, by Lord Selborne, then President of the Board of Agriculture and Fisheries :—

> " It has been part of my duty at the Board of Agriculture and Fisheries to make a study of the agriculture of Germany, and in the course of my work it became apparent to me that, if agriculture had made no more progress in Germany than it has in the United Kingdom during the period 1895 to 1915, the German Empire would have been at the end of its food resources long before the end of the second year of the war, and that, as a matter of fact, the war was being fought by it just as much on an agricultural as on a military organization of the nation."
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> " Accordingly, I asked Mr. T. H. Middleton, C. B., of this Department, to prepare a paper showing what had been the development of German agriculture in the last thirty to forty years and how that development has been accomplished. This admirable memorandum is the result. I respectfully commend it to the attention of Parliament, the Press, and the public."

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* Reprinted from *The Journal of the Board of Agriculture*, vol. XXIII, no. 5, August 1916.

† "The Recent Development of German Agriculture," by T. H. Middleton, C.B., Assistant Secretary, Board of Agriculture and Fisheries (Cd. 8305, Price 4*d*.).

In his memorandum Mr. Middleton remarks that it is frequently stated and commonly believed in this country that British farming is the best in the world. It is certain that throughout the nineteenth century we led other nations. An interesting communication to the old Board of Agriculture contrasts the backward state of German agriculture with the condition of our own at the end of the eighteenth century ; and at the dawn of the nineteenth, the first work published by Von Thaer, who initiated the development of German agriculture, was entitled "An Introduction to the Knowledge of English Agriculture ; containing the latest Practical and Theoretical Intelligence with a view to the Improvement of German Agriculture."

The criterion of good farming in this country at the end of the eighteenth century was success in food production. During the nineteenth century, since we were not dependent on the products of our own soil, the agriculturist's ideals have been modified; and if it be agreed that our claim that British farming is the best means that at the present time we can show very fine cultivation and a high yield per acre of certain crops, that we can produce the best specimens of a large assortment of breeds of live stock and secure for them higher prices than any other country, and that the ordinary machines and implements which we employ are, as a rule, better constructed than those used by farmers in other countries, then British farming undoubtedly still takes a very high place, and is probably second to none ; but if we return to the criterion of success accepted by our own old improvers of husbandry, from whom Von Thaer learned—the amount of the production of food from our soil—then it must be admitted that our position is no longer satisfactory.

Proceeding to deal with the reasons for the great improvement in German agriculture during the past thirty or forty years, Mr. Middleton (1) examines some figures bearing on production in Germany in the past 40 years ; (2) contrasts the main conditions under which German agriculturists and our own farmers work ; (3) refers to the organization of German agriculture ; (4) discusses the effects of German economic policy on the progress of German agriculture ; (5) indicates the methods by which the German farmer

has succeeded in providing food for the rapidly growing population of the Fatherland; and (6) notes some lessons to be learned from Germany.

An examination of the figures relating to production has led Mr. Middleton to conclude that the following statements would appear to be justified:—

On each hundred acres of cultivated land *:—

(1) The British farmer feeds from 45 to 50 persons, the German farmer feeds from 70 to 75 persons.†

(2) The British farmer grows 15 tons of corn, the German farmer grows 33 tons.

(3) The British farmer grows 11 tons of potatoes, the German farmer grows 55 tons.

(4) The British farmer produces 4 tons of meat, the German farmer produces 4¼ tons.

(5) The British farmer produces 17½ tons of milk, the German farmer produces 28 tons.

(6) The British farmer produces a negligible quantity of sugar, the German farmer produces 2¾ tons.

It is shown that the area of cultivated land in Germany has slightly decreased in recent years. The reclamation of moorland, about which we hear much, is interesting as an indication of agricultural energy, but it counts for little in the feeding of the German people. The agricultural population has remained practically stationary. Rather less than more labour is being employed now than 25 years ago. It is, indeed, evident that the larger production has not been due to an increase in the area tilled, or to an increase in the number of persons engaged in tillage, but to better farming; the soil has been better cultivated, crops have been more skilfully manured, plants and animals have been improved in type; the

* Cultivated land includes arable and grass land, but excludes the "Mountain and Heath Land used for Grazing" of Britain and the corresponding "Geringere Weiden und Hutungen" (poor pastures) of Germany.

† These figures are based on the estimate that, of the total "energy value" of food consumed, Great Britain imports on the average about 60 per cent., and that Germany imports 10 per cent. A detailed German estimate is given in the memorandum.

use of oil-cakes and other feeding stuffs has increased; sanitary laws have led to a great improvement in the health of farm live stock. Side by side with these improved technical methods improved business methods have been resorted to, and the profits of agriculture have in turn been employed in further developing the means of production.

A very great deal is clearly shown to be due to the system of agricultural education, an account of which is given; and the following observation by Mr. Middleton almost certainly applies to other agricultural questions besides manures:—"The chief factor in developing the use of artificial manures in Germany, however, was unquestionably a well-organized system of technical education. Investigation at the research stations established the precise uses of these manures; trustworthy advice was supplied by institutions, by peripatetic instructors, by technical leaflets and by agricultural newspapers; and the farmer, even the backward *Bauer*, like other Germans, brought his methods into line with 'Authority.'"

Touching on lessons which may be learned from a study of the progress of German agriculture, Mr. Middleton concludes:—

1. The German farmer now produces about the same weight of cereals and potatoes per acre as the British farmer; but a much greater weight per 100 acres of cultivated land. The German produces about the same weight of meat and nearly twice as much milk per 100 acres as the British farmer. The German feeds from 70 to 75 persons per 100 acres of cultivated land, the British farmer feeds from 45 to 50.

2. The ascendency of the German has been gained in the past 40 years.

3. The soil and climate of Germany are less favourable to agriculture than those of Britain.

4. The actual methods of tillage adopted in the growing of corn, potatoes, etc., in Britain are not inferior to the methods adopted in Germany. The difference in production is chiefly due to the circumstance that in Britain more than two-thirds of the cultivated land is now in grass, while in Germany less than one-third of the cultivated land is in grass

There has been a slight decrease in the area annually ploughed in Germany; in England and Wales the area which is annually ploughed decreased by about 26 per cent. in the forty years before the war.

5. A comparison of the main features of the agriculture of the two countries is given largely in the form of tabular statements. It is pointed out that German land is mostly tilled by peasant owners, British land by tenants. The German depends to a great extent on women labour, provided by the families of the occupiers. Wages are relatively low in Germany, and rural industries help to provide winter employment and tend to cheapen summer labour.

6. Much attention has been given to organizing production from German soil. The credit system is well adapted to promote good farming. Co-operation is largely resorted to. Education has been well developed. Societies have been created to provide leadership.

7. German economic policy in recent years has favoured agriculturists, who have benefited partly from the higher prices resulting from tariffs and partly from the steadying effect which the known policy of the State has had upon the industry.

8. The general effect of the agencies and influences mentioned in the two preceding paragraphs has been to produce a very rapid improvement in the technical methods of the German farmer; the use of manures and feeding-stuffs has greatly increased. Superior strains of both plants and animals have been raised. Business methods have been introduced and important rural industries have been developed.

Mr. Middleton feels that his account of the rapid progress of the German agriculturist may perhaps give the impression that he is now much more skilful than the British farmer, and is careful to point out that such a conclusion would not be fair to the latter. In some respects the German does his work better; notably, he resorts very freely to co-operation, and thus the peasant is enabled to buy and sell as advantageously as the large farmer; again, though the

German peasant is neither scientific in his methods nor teachable, he has more regard for "authority" than the English farmer, and adopts the advice provided for him by chambers of agriculture and societies. Mr. Middleton finds no reason for discouragement with our own position. We have not lost the art of good husbandry, but have modified our methods for reasons sufficiently obvious, and, if after the war the British people make a new demand upon the farmer, Mr. Middleton sees no reason to suppose that he will fail. If, however, the farmer is called upon to modify the methods which have been forced upon him since 1879, by the loss of capital and the relatively high cost of labour, there must be a change in the policy of the country.

The clear lesson which we may learn, if we wish to learn, from German experience is that if we desire to make any considerable addition to our home-grown supplies of food we must as a nation adopt the old farming motto "Speed the Plough."

In the memorandum an attempt has been made to indicate the factors which have been responsible for the success of the "plough" policy of Germany. Among them all Mr. Middleton points out that two are fundamental. Without security for capital and sufficiency of labour the extension of arable farming is not possible. This is in one sense a truism, but behind the truism there are points which are often forgotten and for which provision must be made in any policy that seeks to develop food production.

"If one attempts to summarize in a paragraph the impressions produced by a study of the recent progress of German agriculture, the conclusion is that from the agricultural policy of Germany we may learn something, and from the admirable machinery—administrative, educational, and commercial—set up to lead, teach and finance agriculturists we may learn much. On the other hand, from the actual processes of German husbandry there is relatively little to learn. In many parts of Britain the tillage of the soil and the management of stock are as good as anywhere in Germany. When we set about increasing the food supply of the country we may find examples of the necessary methods without looking across the Rhine."

A Conference of cotton growers and experiment station workers in the West Indies was held in March last at which many important papers were read. These have been published in the *West Indian Bulletin*, vol. XV, no. 4 from which we reproduce the following two papers as they are of considerable interest.—[EDITOR.]

SOME LINT CHARACTERS OF SEA ISLAND COTTON.

BY

S. C. HARLAND, B.Sc. (Lond.),

Assistant Agricultural Superintendent, St. Vincent.

Introduction. It is now generally accepted by the majority of cotton workers that further advances in the quality of the cotton now grown can only be made (*a*) by a biological analysis of the mixed races with which we are now dealing and isolation of the best biotypes by self-fertilization, and (*b*) synthesis of pure strains for the purpose of combining desirable qualities.

The latter work will undoubtedly find a place in the near future, since it is almost impossible to find plants possessing all the characters wanted. We should not expect to find the ideal cotton plant in a mixed strain, since it would have to consist of a homozygous combination of a large number of units. Occasionally superior types of cotton appear in a mixed variety, and these have been considered to be mutations. It is better perhaps to keep the term mutation for a discontinuous modification occurring in a pure strain, and the so-called mutations must then be regarded as rare combinations of already existing units.

For the present we have to rely for our superior types on the results of Mendelian segregation following the planless crossing in Nature. It is evident that more rapid advance could be made by a planned and controlled crossing of biotypes of known value.

In selecting cotton, the great difficulty of all plant breeding work must be faced: *i.e.*, Has an advance been made? Besides paying attention to yield and disease resistance, we seek also good lint and seed qualities. The most important lint characters appear to be these: (*a*) length, (*b*) strength, (*c*) fineness, (*d*) uniformity in respect of (*a*), (*b*) and (*c*). It is also regarded as desirable to have a low percentage of weak fibre, (*e*) a large weight of lint per seed, and (*f*) a large ginning out-turn. Other properties such as (*g*) the amount of twist, and (*h*) the clinging qualities, are important. The question arises, to what extent can workers in the West Indies use these characters as a basis on which to select cottons. Eliminating (*g*) and (*h*) on account of the fact that their value compared with other characters is uncertain, and also because no methods of dealing with them have been devised, we have to consider the remaining characters. It is practicable to examine cottons for length and for uniformity in length, for weak fibre (provided that it is proved to be worth while), weight of lint per seed and ginning out-turn. Strength (meaning yarn-strength) and fineness (which has been shown by Balls to depend largely upon hair-strength), are qualities which can probably be brought out best by subjecting the cottons under examination to practical spinning tests.

In these notes will be considered some of the lint characters of cotton and their bearing upon the work of selection.

Length. The mean maximum length of the fibre is known to be a hereditary character which is subject to environmental modification, and in a pure strain, to fluctuation. Balls[1] considers that if the lint on five seeds be combed out and the average length obtained, the results will show a probable error of $\pm 2{\cdot}9$ per cent. on a mean of 35 mm.

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[1] Balls, W. *The Cotton Plant in Egypt.*

An examination of the mean maximum lint length of 100 seeds from a single Sea Island plant gave the following results :—

(1) The mean maximum lint length on individual seeds varied from 44 to 50 mm.

(2) The probable error in taking the mean of five seeds as correct varied from 2·8 per cent. on a mean of 47 mm. to 0·6 per cent. on a mean of 47 mm. to 0·6 per cent. on a mean of 45·4 mm.

(3) The mean of five seeds ranged from 44·8 mm. ± 1·3 per cent. to 47·8 mm. ± 2·6 per cent.

These results show that for the determination of mean maximum lint length it is sufficient to measure the length on five seeds to give a result which is fairly accurate for comparative purposes.

Uniformity of length. If the lint on a seed be combed out wing fashion at each side, it will be seen that the longest fibres spring from the posterior end of the seed and that there is a gradual reduction in length as the anterior end is approached. Thus some idea of the uniformity of length may be obtained from the mere appearance of a number of combed seeds. It is found, however, that this method is unsound, even for comparative work, since often a large number of short fibres are hidden among the long ones. The only accurate way of estimating uniformity of length is to pull out all fibres of, say, over 40 mm. from the combed seed, weigh this as "available fibre" and express it as a percentage of the total fibre. Different standards could be adopted according to the cottons dealt with. For superfine cottons a minimum length of 45 mm. might be adopted.

The results of determining the percentage weight of fibre above 40 mm. on 100 combed seeds from a single Sea Island plant are, briefly, as follows :—

(1) The average ranged from 37·3 per cent. to 50·2 per cent. in twenty groups of five seeds, with a maximum probable error of 7·1 per cent. of the mean.

(2) When groups of ten seeds were taken, the maximum probable error was reduced to 3·5 per cent. of the mean.

These results show that in comparing the percentage of available fibre from different Sea Island cottons, it is ordinarily sufficient to take the mean of ten seeds. Ordinary Sea Island plants were found to range in percentage of available fibre from 5 to 80 per cent. For purposes of selection it might be advisable to discard plants having less than 65 per cent., unless there were many other compensating qualities.

Weak fibre. In combing the lint upon a seed, the procedure is to pass the comb through the fibres, near their place of origin on the seed, and having carefully cleared this area, to grip the fibres with the fingers and comb out the rest of the lint with more vigour. The fibre that comes away is supposed to be composed chiefly of weak and immature fibres which would, in the ordinary course of events, be useless for spinning purposes. Due regard must be paid to the fact that the quality of possessing fibre which is easily or difficultly separable from the seed is a hereditary one, and easily separable lint does not necessarily imply a large proportion of weak and immature fibre. Some cottons are met with, excellent in length and uniformity of length but possessing a large proportion of 'weak fibre.' In the majority of these cases the high proportion of 'weak fibre' is fictitious, since it is impossible to separate the fibres near the seed without causing large numbers of them to be detached. Finger tests show that in such plants the detached fibres are, as a rule, little inferior to those remaining on the seed.

Fluctuation in weak fibre from seed to seed of the same plant is very great, and the results of weak fibre estimation of 100 seeds from the same plant showed that the mean of five seeds ranged from 5·4 to 14·2 per cent., with a probable maximum error of 14·6 per cent. of the mean.

To reduce the error to even 4 per cent. it would be necessary to comb twenty-five seeds carefully—no mean undertaking when a large number of plants are to be examined.

Considering that the estimation of available fibre would provide more valuable data and could be done using only ten seeds, it would probably be wise to do away with weak fibre determinations

altogether. It is, however, just as difficult to estimate available fibre as it is weak fibre in plants with easily separable lint, and this difficulty can only be got over by selecting plants with lint that is difficultly separable from the seed.

Lint index and lint percentage. The lint index of a cotton plant is defined as the weight in grams of the lint taken from 100 seeds. It has been stated by Cook[1] that continuous selection for high lint percentage is unadvisable since a high lint percentage usually implies a light seed, and light seeds being small seeds, they will give rise to plants which are lacking in vigour. Cook's position is by no means sound, for the following reasons :—

(1) A high lint percentage does not imply a low seed weight. The lint percentage of Sea Island cottons ranges from 19 to 32. Plants with lint percentage of 30 to 32 have been found with average seed weights of 0·115 gram, 0·117 gram, 0·121 gram, 0·129 gram, etc., while plants with lint percentages of 19 to 21 possessed average seed weights of 0·134 gram, 0·086 gram, 0·097 gram, 0·116 gram, etc. These are not exceptional plants, for the results of examination showed that unless the seed weight was abnormally high, there was no relation between the lint weight and seed weight. If plants with high lint percentage are selected, their seed weight is, as a rule, quite normal.

(2) Plants with a low seed weight do not give rise to progeny deficient in vigour. Vigour seems to depend more upon specific gravity of the seed than on its actual weight. Experiments have shown that seeds of high specific gravity germinate quicker and better than those of low specific gravity, and give a much better stand. Furthermore, some strains of vigorous constitution have a low average seed weight; other strains, less vigorous, have one much higher. Thus, the most productive variety of cotton in St. Vincent, the B. S. variety, has seeds of an average weight of only 0·105 gram, as against an average weight for the whole island of about 0·115 gram.

[1] U. S. A. Dept. of Agric. Bulletin: *Danger of Judging Cotton Varieties by Lint Percentage.*

(3) When cottons with high lint index are selected, they are usually found to possess a high lint percentage. Thus out of 120 selected plants the six plants with the highest lint index contained five out of six plants with the highest lint percentage, *i.e.*, there does exist a definite correlation between lint index and lint percentage.

In selecting cottons a high lint index is desirable, since if the number of seeds per boll remained the same, more cotton per boll would be produced and labour in picking economized. There is a danger in selecting on a high lint index alone, for certain Sea Island plants possessing Upland blood to inherit the coarse fibre and high lint index of the latter variety. The superfine cottons of St. Vincent have in general a lint index which is comparatively low. Great care must therefore be exercised in using lint index as a basis for selection. It should be kept quite subsidiary to length and uniformity of length.

In regard to the number of seeds to be taken for lint index determinations, it is sufficient to take 100 seeds. The probable error in this case is about 2·1 per cent. of the mean.

NOTES ON THE DESTRUCTION OF COTTON BUSHES BY BURNING.

BY

F. R. SHEPHERD (St. Kitts)

OWING to the prevalence of certain pests such as leaf-blister mite and black scale, which attack the growing plants of cotton, it has been the general custom, in the past, especially where successive crops of cotton are grown on the same land, to destroy the cotton bushes by burning, with the object of eradicating the pests. The cotton bushes have been generally pulled off and burnt a month or so before next planting.

In St. Kitts, with the estate system of cotton planting, where cotton is only planted in the same field at intervals of about two or three years, the custom has always been to bury in the cotton

bushes as green manure, and not to burn them, it being considered that there was no danger from pests being carried on after so long a time.

On the experiment plots at La Guérite, the cotton bushes have always been pulled off and burnt, until the last two years when they have been buried in as green manure. The reason for this change was the result of observations made on a neighbouring field of old cotton bushes which was severely attacked by leaf-blister mite. In this case the cotton bushes were turned under the banks as green manure and the cotton seed sown at the same time on the centres of the cross holes. It was naturally supposed that this practice was entirely wrong and that the young plants would be attacked by the mite as they came up. This however did not happen, as the mite did not attack the plants to any greater extent than is usually the case.

From this somewhat large experiment it seemed to me sounder, from an agricultural point of view, to bury in the bushes than to burn, if the danger of infection from leaf-blister mite was not present in any greater degree than when the plants were burnt, and for the last two years the cotton bushes have been turned under the banks at the experiment plots at La Guérite about six weeks before the land was again planted in cotton. When the bushes are to be buried, care should be taken to pull them off and not cut them down, as in the latter case there is a risk of shoots coming up from the old stump, which always carry on the mite.

Where possible the bushes should be turned under at least six weeks to two months before the planting of any new cotton, to enable them to rot down and so lessen the chance of any fermentation being present to injure the seed planted, and to minimize the risk of the mite being still living when the cotton is planted.

If the precautions mentioned above are carried out, I am of opinion that the practice of burying in the cotton bushes as manure is very much more beneficial to the next crop than the past custom of burning the bushes. From observations made at La Guérite, I am convinced that there has been no increase in leaf-blister mite since the bushes have been buried in.

A NATIONAL STATUTORY BOARD OF SCIENCE AND INDUSTRY.

In its issue of 3rd August, 1916, *Nature* publishes the following memorandum, received from the British Science Guild, on the relations which should exist in future between the State and Science, and suggesting that a national Statutory Board of Science and Industry should be formed. The memorandum, which has been forwarded to the Government, is signed by some 220 of the most important representatives of industry, science, and education.

"The British Science Guild, which was founded in 1905 with the object of bringing home to all classes "the necessity of applying the methods of science to all branches of human endeavour, and thus to further the progress and increase the welfare of the Empire," is of opinion that the present European crisis affords a unique opportunity for impressing upon all who are engaged in the executive functions of government, as well as upon those who are concerned with industry and commerce, the paramount importance of scientific method and research in national affairs.

There has been much discussion upon these matters, and the following conclusions are submitted by the Guild as representing authoritative opinion :—

(*a*) The material prosperity of the civilized world during the past century is mainly due to the application of science to practical ends.

(*b*) While we stand high among all nations in capacity for original research, as represented by the output of our scientific workers, this capacity has been comparatively little utilized in British industry.

(*c*) The State has neglected to encourage and facilitate scientific investigation, or to promote that co-operation between

science and industry which is essential to national development.

(*d*) Modern conditions of existence demand that instruction in science, and training in scientific method should be a fundamental part of education.

(*e*) The present control of all stages of educational work, from the primary school to the university, mostly by men who have an inadequate appreciation of the meaning and power of science, is largely responsible for the unsatisfactory preparation commonly provided for the work of life.

Since its foundation the British Science Guild has urged that, in the interests of national welfare, serious attention should be given to these defects, and steps taken to remedy them. The establishment of the scheme for the development of scientific and industrial research, under a Committee of the Privy Council, is a welcome recognition of the intimate relations between scientific investigation and industrial advance; and the Advisory Council which advises the Committee as to the expenditure of the sums provided by Parliament, amounting for the year 1916-17 to £40,000, has already been responsible for the institution of researches which should lead to most valuable industrial results. The outlook of the Council may, however, be extended profitably in several directions; for it should be even more comprehensive than that of the Development Commission, which provides for the development of rural industries, among other matters. This Commission, with the Board of Agriculture and Fisheries, and the Imperial Institute which has recently been transferred from the Board of Trade to the Colonial Office, is not concerned directly with manufacturing industries, upon which so large a part of the nation's prosperity depends.

The field of the Privy Council Committee and its Advisory Council is thus distinct from that of any existing State department; and it should embrace all progressive industry and science. It is suggested that a Board or Ministry is necessary to discharge the functions indicated in Clause (i) of the recommendations subjoined, in such a way as to fulfil modern requirements.

(i) A national Statutory Board of Science and Industry, the permanent staff of which should consist mainly of persons of wide scientific knowledge and business experience, should be established to :—

(1) Promote the co-ordination of industrial effort.

(2) Secure co-operation between manufacturers and all available laboratories of research.

(3) Co-ordinate, and be the executive centre of, such joint-scientific committees as have been formed by the Royal Society, the Chemical Society, and various trade and educational associations.

(4) Undertake inquiries as to products and materials, and generally to serve as a national bureau of scientific and industrial intelligence.

(5) Collect and publish information of a scientific and technical character; and provide so far as possible for the solution of important problems bearing upon industry.

(6) Institute a number of paid advisory committees consisting of men of wide scientific knowledge assisted by expert investigators and technologists who should receive reasonable fees for their services.

(7) Organize scientific effort on the manufacturing side and in commercial relations with other countries.

(8) Arrange measures for the mobilization of the scientific, industrial, and educational activities of the nation so as to ensure ready response to national needs and emergencies.

(9) Encourage investigation, and, where necessary, give financial aid towards the synthesis and artificial production of natural products and for other researches.

Such a Board would naturally administer the scheme of the Privy Council Committee, as well as take over certain functions of existing departments and boards.

The functions of the Board would be much the same as regards the promotion of scientific and industrial research and training, the co-operation of universities with industries through trade

associations, and the maintenance of a record of scientific and technical experts, as outlined in the report on "British Trade after the War" by a Sub-Committee of the Board of Trade.

(ii) In all departments of State in which scientific work is carried on, adequate provision should be made for the periodical publication and wide distribution of bulletins, leaflets, and reports, so that increased public interest and attention may be encouraged in the results.

(iii) Every industrial undertaking, subsidized or otherwise assisted by the State, should have upon its board of directors men who possess expert scientific knowledge of the business in which they are engaged.

(iv) In order to develop industries which especially require the services of scientific workers, adequate remuneration and improved prospects should be offered by the Government, by municipal corporations, and by manufacturers to men who have received an effective scientific training. Means should be found of compensating and rewarding persons whose researches have proved of decided national or public advantage without being profitable to themselves.

(v) A knowledge of science should be regarded as an essential qualification for future appointments in the departments of the public service concerned with industrial, scientific, and technical developments. The Royal Commission on the Civil Service recommended in 1914 that a Committee should be appointed to consider the present syllabus of subjects of examination for clerkships (Class I). This Committee should be constituted without delay, and science as well as other branches of modern learning should be adequately represented upon it, and upon the Civil Service Commission itself.

(vi) Measures should be taken to revise the educational courses now followed in the public schools and the Universities of Oxford and Cambridge.

(vii) In elementary and secondary schools supervised by the Board of Education, more attention should be given to scientific method, observation, and experiment, and to educational handwork."

A TABLE OF RELATIVE VALUES OF SOME CONCENTRATED CATTLE FOODS.*

BY

O. T. FAULKNER, B.A. (Cantab.),

Deputy Director of Agriculture, Punjab.

IN lecturing at the Lyallpur Agricultural College and in connection with the dairy at that College the need has been felt of some means of comparing the values of different Indian cattle foods. This want can only satisfactorily be filled by the results of research similar to those conducted by Kellner and others on the values of European concentrated cattle foods. However, at the suggestion of the Professor of Agriculture, Lyallpur, an attempt has been made to compare the values of Indian foods by using such data as are available. The relative values assigned by experimenters in Europe and America to the various foods depend on determinations of the amount and the digestibility of the valuable constituents in the different foods; on estimates either of the relative values of these several valuable constituents to the animal or of their approximate costs in foods of the given type; and lastly, on determinations of the amount of energy apparently spent, and therefore wasted, by the animal in masticating and disintegrating the foods in question. In attempting to arrive at some basis for comparing the values of various foods available in India the only data that seem to be useful are the determinations of the total valuable constituents of Indian foods by Dr. Leather and the values found by European and American experimenters for the digestibilities, etc., of more or less similar foods used in their countries. It is felt

* Reprinted from the *Journal of Dairying and Dairy Farming in India*, vol. III, part 2, January, 1916.

that these data are not sufficient to form any basis for the comparison of the bulky fodders available in India. But an attempt has been made to arrive from these data at figures, which may give a rough guide to the relative value to cattle of the various concentrated foods, which are available in India.

This attempt has resulted in the completion of the table given on the next page.

Columns 1 to 4 inclusive are extracted from Dr. Leather's "Average analyses" (*a*) (the figures being given only to the nearest ½ per cent.), except in the case of the last three oilcakes, where Kellner's figures (*b*) are used.

The amounts of valuable digestible constituents (columns 5 to 7) have been calculated by the use of tables of digestibility given either by Kellner or Henry (*c*); the authority in each case is stated in the last column. For the first five grains the figures for the digestibility of the valuable constituents in cowpeas have been used in the absence of any figures relating to these grains which are more or less peculiar to India.

Column 8 gives the starch equivalent of these amounts of valuable digestible constituents. But the method of calculating this is different from either of the methods commonly used in Europe. Two methods are there in vogue. In the first, based on the respective values of these constituents for the production of fat on a bullock, the equivalents used are :—

1 per cent. Digestible Carbohydrate				1 per cent. Starch.		
1	„	„	Protein	.. 0·95 or 1	„	„
1	„	„	Oil	.. 2·1 or 2·4	„	„

The equivalents more commonly used in England represent an attempt to take into consideration, not only the values of these ingredients to the animal, but also the relative cost of buying them. They are :—

1 per cent. Digestible Carbohydrate				.. 1 per cent. Starch.		
1	„	„	Protein	.. 2¼	„	„
1	„	„	Oil	.. 2¼	„	„

Protein is given a value equal to that of fat on account of the high prices of highly nitrogenous cattle food in England; and

TABLE I.

	1	2	3	4	5	6	7	8	9	10	
	Total oil	Total albuminoids	Total soluble carbohydrates	Total fibre	Digestible oil	Digestible albuminoids	Digestible carbohydrate and fibre	Energy value (starch=100)	"Kellner's value"	Comparative value (starch=100)	Authority for Digestibility figure.
GRAM MEAL. (Cicer arietinum) ...	4·5	18	58	6·5	3·5	15	58	84·5	95	**80**	Henry—for cow per meal.
GUAR MEAL. (Cyamopsis Psoralioides) ...	3	27·5	48	8	2	22	49·5	77·5	95	**73**	,, ,, ,, ,, ,,
MOTH MEAL. (Phaseolus aconitifolius) ..	1	20	60·5	4·5	0·5	16·5	60	81·5	95	**77**	,, ,, ,, ,, ,,
MASH MEAL ("URD")... (Phaseolus Mungo) ..	1	20·5	60	4	0·5	17	58	80·5	95	**77**	,, ,, ,, ,, ,,
MUNG MEAL. (Phaseolus radiatus) ...	1	21	60	4	0·5	17	58	80·5	95	**77**	,, ,, ,, ,, ,,
COTTON SEED. (Gossypium herbaceum) ...	18·5	17·5	31	19	16	12	30	81	95	**77**	Kellner.
LINSEED. (Linum usitatissimum) ...	40 5	18	26	5·5	35	16·5	17·5	117	100	**117**	,,
BARLEY. (Hordeum vulgare) ..	2	6·5	71·5	4	2	4	68	79	100	**79**	Henry.
MAIZE. (Zea Mays)	5	9·5	71·5	1·5	4·5	6	69	86·5	100	**86**	Kellner.
JUAR. (Andropogon Sorghum) ...	4	10	72·5	1·5	3	5	62·5	74·5	100	**74**	Henry.
WHEAT BRAN ...	3·5	13	58·5	8·5	2·5	10	44	62	80	**50**	,,
COTTON CAKE. (Machine made from undecorticated seed) ...	6·5	24·5	26·5	25		18	17·5	53·5	85	**45**	Kellner.
LINSEED CAKE. Machine made) ..	8·5	33·5	31·5	8·5	8	29	29·5	84	95	**80**	,,
RAPE CAKE ...	10	33	28	11	8	27·5	23	75·5	95	**72**	,,

because a certain amount of protein is indispensable for the rations of all kinds of stock—an amount which is large in the case of young animals or milking cows.

The first standard appears unsuitable for the present purpose, because cattle in India are very rarely fed for the special purpose of providing beef. The second method appears undesirable for comparing Indian foods : because a consideration of the figures of valuable digestible constituents in various foods leads to the conclusion that protein is not very dearly bought in Indian cattle foods. For instance gram contains much more protein than barley, the amounts of fat and carbohydrate being much the same ; and the relation between ordinary prices of these grains will not suggest that protein is a much more expensive substance than digestible carbohydrate. The equivalents used in the preparation of this table are :—

1 per cent. Digestible	Carbohydrate	..	1 per cent. Starch.
1 " "	Protein	..	$1\frac{1}{4}$ " "
1 " "	Fat	..	$2\frac{1}{4}$ " "

These figures roughly represent the relative values of these constituents for the production of heat or energy in cattle. This, it is suggested, is the best standard for comparing cattle foods in India. It seems obviously to be the best method to use when judging the value of food given to working cattle. Their food is mainly used for the production of energy ; and their comparatively small requirements of protein are not likely to be unprovided for in any ordinary ration. The amount of protein necessary for milking cows is much higher. But since, as has been pointed out, this ingredient is not unduly dear in Indian cattle foods there should be little tendency to supply an insufficient quantity of it. Thus there appears to be no need to place a very high value on it when comparing foods, provided that the necessity for giving it in sufficient quantity be not overlooked.

Column 9 gives in round figures the " Kellner's value " for these different foods. " Kellner's value " here means that percentage of the value of the digested constituents, which is found to be used by the animal for useful purposes. These figures have been

obtained by Kellner and other workers by comparing the increase of weight actually made by the animal, when given these various foods in addition to a basal maintenance ration, with the increase which would be expected from a consideration of the starch value of the digested constituents (as given here in Col. 8). Thus the figure for linseed is 100 : this means that the value of a pound of linseed to a bullock is, as nearly as can be ascertained, the same as the value of all the oil, protein, and carbohydrate, which he can digest from that linseed. But the " Kellner's value " for bran is only 80, because it is found that an animal puts on, as a result of eating a pound of bran, only 80 per cent. of the increase in weight, which he will put on if supplied with as much pure digestible oil, protein, and carbohydrate as that pound of bran contains. (It is assumed that the other 20 per cent. of the value of the food, which appears to be lost, is expended by the animal in the mechanical work of chewing and breaking down the bran itself for digestion.) The figure 95 used in this column for gram, *guar*, *mash*, *moth*, and *mung* is an average of the figures given by Kellner for different kinds of beans, peas, lupines, etc., which vary from 89 to 99. The remainder are approximately the figures which he gives for the same kinds of grain or cakes as obtained by him in Europe.

Column 10, obtained from columns 8 and 9, therefore gives the values of these various foods to cattle, for the production of energy, compared to the value of starch (= 100) for the same purpose, as nearly as can be ascertained from the data available and here used.

Figures so obtained can obviously only represent an attempt to form a rough basis for the comparison of these foods as obtained in India. Especially the figures for gram, *guar*, *mash*, etc., must perhaps be regarded practically as guesses, since the results of no digestibility or " Kellner's value " tests of these foods are apparently available. Yet, until the results of actual experiments are available, these figures of " Comparative energy values " of these foods may be of use, since the prices of even very similar foods, at different times and places in India, are liable to variations far greater than the probable error in these figures. It is perhaps unnecessary to

emphasize the fact that such figures only represent the values of the foods as so much fuel, as it were, to the animal: whilst the practical feeder has also to bear in mind other considerations—such considerations as the necessity of providing palatable and healthful rations, as well as supplying enough protein, especially for milking cows and growing cattle. For instance, rape cake, apparently, from these tables, often a most economical food, must be used with discretion: whilst bran, though it may be, judging from these figures, very dear, may yet be worth its price on account of its almost medicinal effect.

In Table II the respective values of these foods, when gram costs Rs. 2-8 per maund, are given as calculated from this table.

TABLE II.

	Rs.	A.	P.
Gram	2	8	0
Guar	2	4	6
Moth	2	6	6
Mash	2	6	6
Mung	2	6	6
Cotton Seed	2	6	6
Linseed	3	10	6
Barley	2	7	6
Maize	2	11	0
Juar	2	5	0
Wheat Bran	1	9	0
Cotton Cake	1	6	6
Linseed Cake	2	8	0
Rape Cake	2	4	0

REFERENCES TO LITERATURE.

a. Leather, J. W. Agricultural Ledger (India), No. 10 (1901) and No. 7 (1903)
b. Kellner, "Scientific Feeding of Animals," Translation by W. Goodwin.
c. Henry, "Foods and Feeding," 1910.

[*Note.*—We welcome the plucky attempt which has been made to overcome a difficulty by the compilation of the tables given in this article which we feel will be of great use; and we shall be interested to see in the future when the real relative values are ascertained how far they differ from the assumed values taken by Mr. Faulkner.—(EDITOR.)]

POULTRY—WHAT TO BREED AND HOW TO MANAGE THEM.*

(*Lecture by Mr. A. C. Bullmore at the Madras Exhibition, January* 1916.)

YOUR EXCELLENCIES, Mr. Chairman, Ladies and Gentlemen,—The subject selected for this evening's lecture, as you know, is about "Poultry—what to breed and how to manage them." In dealing with it I must apologize for the hasty manner in which I was compelled to prepare a subject of such intense interest and importance as this for your consideration this evening. My time has been so fully occupied in preparing separate exhibits for the present Show, that for the past ten days I have hardly had any time to devote to this subject. I must, therefore, ask you to kindly overlook any shortcomings in my treatment of it.

In this lecture it will be my aim to present, in as brief a manner as possible, the main features of successful poultry raising. The novice may be enthusiastic, but his enthusiasm may lead him to underestimate the value of careful selection and management. The majority are under the impression that rearing of poultry requires no special knowledge or experience. Many are, therefore, led into the business not only with erroneous ideas, but have exaggerated views of the profits to be derived from it.

Many people, especially those living in the country, still keep on in the old ruts, breeding and managing without system. If successful and profitable poultry are wanted, they must have the same attention and proper management as any other stock. Those who think that there is nothing more to be done than to put a few fowls in a shed, and to throw a little corn at them two or three

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times a day in order to secure an abundant harvest of eggs, are sadly mistaken. Fowls can only be kept profitably by systematic management, and anyone who has not time or is not prepared to go to the trouble of keeping them properly should not keep them at all. Poultry-keeping, taken generally, is a subject which bears a double aspect, and is to be regarded from two points of view. From one point, it is to be viewed as a hobby, taken up and handled for the pleasure that is to be derived from it. From the other, it is to be considered as an employment, followed sedulously as a means of livelihood and pursued for the profit and emolument it will yield.

First, let us look at it as a hobby, as a means wherefrom to gather enjoyment, and a mode for whiling away many a passing quarter of an hour, which might otherwise be wasted and thrown away. It gives those who follow it something to think about at early morning, at mid-day, perhaps, and in the evening when the daily work is done, and the emp'oyment from which the means of living are obtained is put aside for the time, to be taken up again on the following day with increased zest and pleasure, by reason of the change of thought and change of work to which recourse has been had in the interim, a change that has led to the recreation and recuperation of body and mind and has taken the thoughts into other channels by which they are refreshed and restored from the daily cares inseparable from bread-winning and the daily struggle for life.

In all probability the fowls are kept in confinement in a small run devoted to their safe keeping, and a means of preventing them from doing any mischief to the owner's garden, if he has one, or to the gardens of his immediate neighbours. Well, in this case there will be often something in the run and the poultry shed itself that demands attention, a little bit of mending, involving manual labour here and there, renewal possibly in one part and improvement or enlargement perhaps in another. There is pleasure to be gained from the pleasure in thinking out what is to be done, and pleasure in doing it after it has been thought out.

The selection of the best breeds depends upon the tastes and opinions of people. Some may choose to rear many breeds together,

others again prefer a pure black coloured breed, whereas some prefer a spangled or spotted breed, and some a pure white. Then there are the different objects of keeping fowls. Some keep them solely for the table, some only for pleasure and merely to look at, whereas others again, the majority, keep poultry to make a big business in breeding and selling, which is the most profitable and pleasing, I fancy. The best fowl to keep and breed, I should say, is the fowl of the day. All poultry are layers, but there are some breeds which have won a name for themselves in every way and mostly in their laying qualities. Laying is a matter of strain rather than breed ; for in every breed there are good, bad and indifferent layers ; but there is little doubt that there are certain breeds from which there is a better average result than from others.

I am often asked which I consider the best general-purpose fowl. Well, I should think, taking all in all, as regards colour, size, shape, laying qualities, and a good hardy breed, the Orpington class will more fully meet the demands of the person who wants to keep one variety, such as the Buff or White Orpingtons. Indeed there are other breeds, but the above-named varieties are a long neck ahead of the English Class. The White and Buff Orpingtons are hard to beat for an all-round general-purpose fowl, especially when they have been bred in line for laying. Several things are to be considered in choosing a breed of fowls. First, what is your object in keeping fowls ? Do you want to keep them for eggs and table, or do you look upon the fancy part of the business ? Have you one acre of ground, or is it ten acres ? Possibly it is only the back part of your house.

There are breeds of fowls to suit all these conditions if you will only give a little study to the situation. A person must have an object in view and work all the time to that end to make much of the success of the chicken business as well as anything else. If you have plenty of room—say five or ten acres—and want to keep chickens just for fresh eggs for the table, I would say select one of the smaller breeds of the Mediterranean type ; for instance, the Leghorns or Minorcas ; for with plenty of range they have been proved to be splendid layers and great foragers, but they must have

room to do much good. I think any good breed of standard fowls will suit for the fancy business, if you can provide the conditions that suit the fowls, but right here is where you must do a little thinking.

Don't make the mistake of trying to raise small breeds in close confinement or the big Asiatic breeds with too much free range. If you are considering the fancy poultry business, just make up your mind as to the kind of fowls you most admire, and the one with which you think you will be successful. Stay with your best choice. If your space of ground is limited, I think it would be wise to take up the breeding of Wyandottes, Orpingtons, or Rhode Island Reds, for these large fowls stand confinement well, and if given the right kind of treatment and good wholesome food they will lay plenty of eggs—in fact they will lay better than some of the smaller breeds under the same conditions. You will have better results and will not be liable to become discouraged. You will do better with about 60 or 70 chickens well attended to, than three or four hundred with the same attention.

The demand for extra choice stock was never so great as it is now and must of necessity be greater day by day. In the first place, there are now more fowls shown than ever before, the number of Poultry Shows is rapidly increasing, and the offerings by the Associations are being annually made more attractive to exhibitors. So it is that the quality of the stock shown is yearly being raised and the demand for good stock is now far greater than the supply.

The present high prices of eggs and poultry will undoubtedly have a tendency to bring many beginners into the poultry world. The first question confronting a beginner will be : "What kind of poultry will be the most advantageous to keep ?" To this, I will say, start right, do not be persuaded to buy mongrels, for the following reasons :—First, it does not cost any more to feed pure-bred birds than mongrels. Second, there is nothing so pleasing to the eye as a flock of birds of one variety. Third, pure-bred birds will lay as many eggs as mongrels under the same conditions. Fourth, eggs from pure-bred birds will bring an equal price for market and a much higher price for hatching. Fifth, surplus cockerels

and pullets of pure breeds find a ready market at a good price. For a stated sum from a dealer you will get quantity when buying mongrels and quality when buying pure-bred stock. It will cost more to start with birds bred to standard requirements, but the results will show in the end that an increased expenditure for pure-bred birds in the beginning is the more economical course. As an illustration, let us take one of the most practical crosses of to-day, that is, the Leghorn male with light Brahma female. It is a well-established fact that a Leghorn hen is the egg machine to-day, and that the Brahma is a bird which looks well on the Christmas table. Knowing the predominant characteristics of these two birds, we will say as a figure that the Leghorn hen lays 260 eggs in a year, and the Brahma, being meaty, lays about 150 eggs per year. The result obtained by crossing the two is that we weaken the laying qualities of the Leghorn, as the pullet from this cross will lay on an average 175 per year and some of the good table qualities of the Brahma are also lost. Eventually nothing is gained, whatever gain there may be in one is lost in the other by this cross-breeding.

If you have never paid particular attention to poultry, but are starting to be interested in the subject, I believe this little talk will do you good. I was a beginner once myself, and know just where all the pitfalls and stumbling blocks in the business are to be found. I know how to get out of them without being bruised and blackened until discouragement looms up higher than a mountain. The trouble with a good many beginners is that they expect too much. I remember when I was exactly in that position I thought all I had to do was to get a few chickens, and take my ease until the rupees began to roll in. You and I will never see the time when poultry and eggs will not be in demand at profitable prices.

This is my advice :—To the beginners I would say, don't expect to get rich the first year, it is better to begin with a small flock or a few settings of eggs from a reliable breeder, and be content with small profits at first. You will be learning all the time how to handle and deal with larger flocks. You will grow into the business and in a very few years be ready to give your whole time to it.

The selection of the male birds is important, as they must be full of vigour. It is always advisable for those who are contemplating the purchase of new stock birds—no matter whether for laying purposes only or for breeding utility birds, or better class birds for exhibition, or those which are required for exhibition at once—to take care to obtain birds which are really suited to meet their requirements, as much disappointment is saved by the exercise of care in this direction. Unfortunately there are many who purchase a small pen of birds on account of their looking nice and being of a moderate price, and they find that they have bought fowls which are costing them money all the time and giving them very little return for it. In the various breeds of poultry we must remember all are not alike. There are some delicate breeds which are pretty to look at and need great care. They cannot stand too much confinement, and it would not be well for people in India to keep them. Probably they could not thrive and are unproductive. They are not worth while keeping except as pets.

The breeds mentioned are all profitable to keep, and it stands to reason which the fancier chooses; and whichever he does care for must always be taken in the mating, breeding, feeding, housing, etc., in order to get a good egg production. But out of all these, if the object of the fancier is to obtain a real large supply of eggs and good birds, to gain a large profit in sale, with the least trouble, the very best breeds to keep would be the Orpington, Wyandottes or Leghorn. A general-purpose fowl and best for table is the White Orpington, its flesh being pure white, juicy and tender.

I shall briefly touch upon just a few useful breeds of fowls. Now we will take the Leghorn family. There are all told six varieties, but I only here mention about four, which prove to be the best and most popular. The six varieties are the Black, White, Buff, Brown, Pile, and Duckwing. The two last I leave out of mention. Leghorns are a very popular breed and have a very good laying quality. The head points of all the varieties in Leghorns are alike. The comb of the cock is single, evenly serrated and erect, while the hen's falls to one side. Their faces, combs, and wattles should be bright red, with white ear lobes. The body should be

small and compact, with short legs and high standing tail, with yellow legs and beak, except that of the Brown Leghorn which should have a brown coloured beak.

Plymouth Rock. These are a useful and a good general-purpose fowl. The hens are very good layers of brown shelled eggs of a good size. Both male and female are hardy, and stand confinement well, if fed properly, although bred to better advantage if kept on a large run. The chickens are easy to rear and fatten easily. There are four recognized varieties, *viz.*, the black, white, barred, and buff. All the varieties are yellow-skinned with yellow beaks and legs, and the Black, White and Buff are self-coloured. The only variety needing mention in plumage is the barred Plymouth Rock, which should be grey white, formed evenly round the body with bars or bands of bluish black.

The Wyandottes. These are a very good breed of fowls, being good table birds, hardy and excellent layers. They resemble the Plymouth Rock somewhat in shape and are very popular. There are four principal varieties mainly, *viz.*, the white, buff, silver-laced, and gold-laced ; but the white seem the best and most popular. The plumage of the white and buff is self-coloured with bright featherless yellow legs, rather short. The plumage of the silver-laced male should be quite silvery, each feather in the lower half of the wing coverts white with black edging ; the hackles silvery white with a distinct black stripe through each feather.

Orpingtons. The sub-varieties of the breed are black, buff, jubilee-spangled, cuckoo, blue and white.

The Black Orpington was the first variety introduced by the late Mr. William Cook. It is an all-round good fowl, a decent layer of brown eggs, and a good table fowl, its flesh being tender and white. The Orpington is in all the varieties a pretty shaped bird, having a full broad prominent breast, short-curved back with a full feathered body, standing on thick short legs. The plumage of the Black Orpington is deep black, with green, sheen free from any other colour.

Of all the Orpington varieties, the White Orpington is the best in every way. It is a very popular fowl, and is becoming more and

more so daily, the reason for which is its undoubted utility qualities. It is quite easy to rear, and hardy, and no layer of brown eggs can equal it in its laying qualities. In plumage it is the prettiest. The White Orpington, the standard of perfection, is snowy white, free from a speck of any other colour; its shape is that of the Black Orpington, being broad breasted, rounded and full; short curved—with a bold upright carriage; face, comb, wattles and ear lobes bright red, pretty red eyes, with short, stout, white legs perfectly free from feathers.

I realize that it is too delicate a subject to speak upon the good point of any one breed over others, as every fancier has his own favourite breed, which generally meets all his requirements. As I have had practical experience with over 20 different popular breeds during the past few years I ought to be in a position to say why I decided on my favourite breed of fowls; and after once coming to this decision, I have kept on improving my stock until my fowls are known all over India. That the White Orpington is the most popular fowl of England to-day, no well-posted poultry man will deny. Its reputation is fast spreading over all parts of the world. There has never been a breed of fowls on record that has originated on the same sound principle as the Orpingtons, for they are what is known as an out-bred breed and has been a result of many years' practical out-breeding, where the poultry raiser's main object is to produce the most eggs and best market fowls at least expense and trouble.

The first and most important subject after the poultry fancier has selected his breed and wishes to gain success is the selection of the poultry houses. They are not very expensive to construct and the regard which all fanciers have for their poultry should carry them to the great interest of seeing to all the requirements and comforts of the birds, which is bound to lead to a profitable and pleasing business.

All poultry houses should be erected under proper supervision, the first to be made is the choice of the ground, and aspect of the house, which should be in an easterly direction. Good hard dry ground is required, which should be raised about 6 to 7 feet above

the level of the surrounding ground, and rammed down well, and loose gravel thrown over this. Artificial flooring such as bricks, boards, tiles, or any kind of stone is not advisable. Bricks are the worst for the floors, as they retain great moisture ; boarded floors are not good as they get saturated with all the excreta of the birds, and cause the atmosphere in the poultry house to be very unhealthy. Tiles are similar to bricks and mean damp flooring. Cement is another floor which people think of, but it makes a very cold one, unless covered with some dry material. So the best flooring for poultry houses would be good hard dry ground, covered over with a carpet of dry earth ; sand is also very nice to spread over, but great care must be taken that the floor is swept out every morning, and fresh sand spread again.

The next step to be considered is the walls of the poultry houses, these can be built either of brick or wood. Some people build with mud walls. I do not advise this because of rats and snakes which might easily get in by boring holes in very quick time. If the walls are built of wood, great care must be taken that each plank is closely joined to the other to prevent big crevices. All the crevices should be filled carefully to prevent draughts, or any vermin resting inside, then the whole of the walls inside properly tarred.

The third step regarding the house is roofing, which is a very important matter. The roof of the poultry house should be made quite sound and attached on well, to stand rough weather and strong winds.

The size of the poultry house should not be extra large. It is a great mistake for people to think they can house all their poultry together in one large room. Too many fowls cannot be placed together in one large room, as it causes unhealthiness to them, and if an epidemic were to break out, such as roup, cholera, pox, etc., there would be very little chance of saving any part of the flock. Separate houses for poultry in small lots are the best, and even more so for those who keep a very large stock. Attached to each house on one side there should be the scratching shed.

Some people imagine that birds do not require much light and air in their houses. This is a very silly impression to be under indeed, and I must mention that birds are as fond of light and fresh air as human beings, and they also need them as much. We cannot expect the fowls to thrive in dark and entirely closed houses. All poultry houses should have a window which can be closed or opened according to the weather, and as the poultry fancier desires it. The width of the perches should be about 2 to 3 inches, the edges should be nicely rounded to allow the birds a good hold. They should be of the length of the room and far enough from the wall to prevent the cocks' tails being destroyed.

The next requirement in a fowl house is the nests. These can be placed near one side of the wall, made from dealwood in the shape of a box, a square large enough for the hen to sit. It should be 6″ deep to hold the straw which completes the nest. Nests can also be made from earthenware, such as a large flat-bottomed *chatty*, 5″ or 6″ deep, and can be filled with fine sand or ashes for the laying hens.

Another matter which should always be considered for fowls in each shed is the dust bath for the birds to roll and bathe themselves in, which helps to cleanse them from any vermin. This should be of very fine dry sand or sifted ashes, or even clean road dust placed in a good heap, which should be renewed daily; and the previous dust bath which has been removed ought to be thrown a good distance away from the fowl yard, in case it should be infested with any vermin. The fowls will be found in their greatest delight bathing and cleaning themselves in the dust bath every day.

The feeding of poultry is a matter that should be well attended to, and nothing but the best of all kinds should be given. Stale goods or old rotten grains are very bad for fowls. One of the chief and most natural foods is grain, though they cannot entirely live upon it; for the fowls also need a fair amount of soft and green foods, but grain ought always to be supplied them at the proper time. There are various kinds of grains and some are more nutritious than others. Many fanciers think that mixtures of grains

are more suitable than supplying each kind separately, but this is not so in every case. It must all depend as to how the poultry keeper finds his birds thriving. Of all grains, wheat is considered the best, either given whole or coarsely ground. Then there are oats, barley, peas, beans, Indian corn, gram, and maize. Oats form a very good food, and nothing equals it for adding size and stamina to young stock. Barley is good when given as barley meal mixed in other food or with skimmed milk or water, but fowls in India will not so readily eat it as a whole grain. Peas and grain are the richest in albuminoids, and are very good for the laying hen. Indian corn is very fattening for fowls, but should not be given very often to poultry kept for breeding purposes.

Another important matter we come to concerning the fowls' food is the green food. Without this it is impossible to keep fowls in perfect health. A daily supply of green food is grass : hence the reason it is so necessary to have grass runs for the birds.

The importance of grit, oyster shell, and charcoal ought never to be forgotten, for in addition to the daily food it is necessary that the fowls be supplied with these. Grit is very important, and you will always find the fowls readily eat it as well as oyster shell and charcoal. We must always remember the fowls have no teeth, and if not supplied with sharp grit they won't be able to digest their food. Grit acts as teeth to fowls, and should not be mixed with the food, but a quantity of it should be placed in the run in a grit box, so that the birds may eat at will.

The morning meal should consist of soft food, given as early as possible. Many people fancy that grain should be the bird's first meal, but this is not correct, as the birds are empty-stomached, having fasted the whole night ; and grain given to them the first thing in the morning takes a long time to digest, and has to be ground in the gizzard first.

The evening meal should be of whole grain thrown to the birds ; allow them to run after it, and pick it at their will, just an hour or so before sunset. The grain is a good thing for the evening meal, as it takes long to digest, not causing the birds to be empty-cropped by morning. All refuse such as scraps of meat, bread

crumbs, vegetable, curry and rice from the table can be given to the fowls.

I shall now give you a bunch of good tips for poultry keepers. Provide gravel, it means teeth. Provide ventilation, it is health. Provide sulphur, it prevents disease. Provide lime and bone, they supply a want. Select the best-shaped and largest eggs from the best layers for hatching. The best absorbers to strew on the floors and under the roosts are sand and road dust. One of the best tonics for chickens, and probably one of the simplest, is to keep a handful of old rusty nails in each dish from which they drink. The rust is the oxide of iron sold by druggists, and the tonic made is as good as the sale article.

I have, within a limited period, given you the bare outlines of how to select a good strain of poultry and how to manage them. There are various other points connected with poultry keeping, such as mating and breeding, eggs for hatching, care and rearing of chickens and diseases of poultry and their treatment. I am afraid if I touch upon all these, however briefly, it may take up too much of your time. I shall therefore close with one request, if you are anxious to become a successful poultry breeder for pleasure or profit, and are doubtful as to the best means of doing it, please come to me, and I shall endeavour my utmost to put you on the right track. In conclusion, I beg to thank you, Your Excellencies, Mr. Chairman, Ladies and Gentlemen, for your kind interest in listening to what to me is an absorbing subject.

SOME RESULTS OF EXPERIMENTS ON THE PALM SUGAR INDUSTRY.

BY

H. E. ANNETT, B.Sc., F.I.C.,

Agricultural Chemist to the Government of Bengal.

AT the meeting of the Bengal Provincial Agricultural Association, held on the 5th July, 1916, under the presidency of the Hon'ble Mr. Beatson-Bell much useful work was done, and the following papers were read :—

(1) Some Results of Experiments on the Palm Sugar Industry, by Mr. H. E. Annett.

(2) The Improvement of the Rice Crop in Bengal by Pure Line Selection, by Mr. R. S. Finlow.

(3) The Improvement of the Jute Crop by Pure Line Selection, by Mr. R. S. Finlow.

As these papers describe the results of work done on these important crops by the officers of the Bengal Agricultural Department and also contain practical suggestions, we propose to reproduce them in this and the April issue in the hope that they will prove interesting and instructive to a large number of our readers. This month we reproduce Mr. Annett's paper.—[EDITOR.]

MR. MILLIGAN has asked me to tell the Provincial Agricultural Association something about the practical results of work I and my assistants have been carrying out on the palm sugar industry.

You must all know that in all countries which possess an Agricultural Department there are two classes of men working in that department. Firstly, the scientific officers who are carrying

out research work, and, secondly, the practical agriculturists. Both these classes are equally necessary. The former expects the agriculturist to bring him problems to solve and also depends on him to demonstrate in the field any discoveries he may make. In India, however, difficulty is frequently experienced in finding the best means of demonstrating what is known to the Agricultural Department as being a definite improvement. It would seem that a great deal in the way of advertisement would need to be done to get the cultivators to make even small changes in their agricultural operations. As I believe we now have something definite in the way of improvements of the palm sugar industry. I welcome this opportunity of pointing out these results here in the hope that some members of this association may be able to help in advertising the facts in the palm sugar districts.

A few words as to the extent of this industry will not be out of place. India's total production of sugar is somewhere about 3 million tons per year. Her palm sugar production accounts for certainly well over 300,000 tons of this total. Bengal produces roughly 100,000 tons of palm *gur* annually worth at the minimum 80 lakhs of rupees or well over ½ a million pounds sterling. It seemed to me that such a large industry ought to receive some attention. As a result of visits to Jessore district in the cold weathers of 1910-11 and 1911-12 a memoir was published by me entitled "The Date Sugar Industry in Bengal, an Investigation into its Chemistry and Agriculture."[1] This gives a very full account of the industry and deals with its development.

As a result of my transfer to Bengal I was again able to spend a good part of last cold weather in Jessore. We fitted up a camp laboratory in the fields and we made large quantities of *gur* both by the native and what we hoped might be improved processes. One experiences many difficulties in working a chemical laboratory in the fields.

The most important recommendation I have to make is that the cultivators should be encouraged to lime the inside of their earthen pots in which they collect the juice. At present all that

[1] *Mem. Dept. Agri., India, Chem. Ser.*, vol. II, no. 6.

the cultivator does is to smoke the inside of the pots before suspending them in the trees. We find that this smoking certainly has a beneficial effect, but lime almost always gives a better juice, and this is especially the case on warm nights and especially towards the end of the season. It will be as well to explain simply the cause of this beneficial effect of the lime. The palm juice contains chiefly cane sugar. There are also other sugars present in the juice usually in very small quantities. These other sugars do not crystallize well and are not so desirable. Palm juice commonly contains living organisms, such as yeasts and bacteria, which live on the sugars. They change the cane sugar into the other sugars which do not so readily crystallize and, if the juice be left long enough, these other sugars are transformed into alcohol. In districts where toddy is made from palm juice, of course the people want these living organisms to grow. Lime kills these organisms, and hence when lime is put into the pots it preserves the sugar in the juice.

In Madras the Excise Department insists on lime being put into the collecting pots where the juice is used for sugar production, and heavy fines are imposed upon persons found disregarding these regulations. As a result one finds that in Madras the cultivators are able to collect all juice from the trees, whether it flows in the day time or at night, and it is all used for sugar production. The Bengal tapper, however, wastes practically the whole of the juice which falls from the tree in the day time. He finds that during the heat of the day the juice deteriorates, and he cannot make good crystalline *gur* from it. He collects the juice from a few of the trees which give a large amount of juice in the day time, and in the evening he boils down this juice which he calls *ola* and obtains a thick treacly mass. This he usually mixes in with his good *gur* which he makes next day, and so lowers the quality of the latter.

We have found, however, that all the cultivator has to do to enable him to produce good *gur* from all his day juice is to lime the pots. In the presence of a number of cultivators we made high class *gur* from the day juice which we have collected in pots which had been previously limed. This little demonstration very much

impressed the men, and we think it will take very little pushing to persuade the cultivator to lime his pots during the day time in any case. We made numerous measurements of the amount of juice which falls from the tree in the day time. It forms about one-fifth of the amount of juice collected at night. At the same time it is considerably richer in sugar than the night juice, so that, by introducing the practice of liming the pots even in the day time only, it seems that the cultivator would increase this out-turn of *gur* by more than 20 per cent.

Another advantage of the lime treatment is that the juice collected during the day in the limed pots can be kept overnight and boiled next day together with the night juice, for we have found that the juice keeps quite well during this period, provided sufficient lime is used. It would be very troublesome for the cultivator to do another large boiling at night.

Fuel consumption. Another point I wish to say a few words about is the question of fuel. Throughout the palm sugar districts wood is practically the only fuel used except for the first month or six weeks of the season, when dried palm leaves are used. It has been said that fuel has been getting scarcer in certain districts of recent years. It would therefore be of advantage if some economy could be introduced. We performed numerous experiments with the idea of finding out how much fuel the cultivator uses to make a maund of *gur*. We cannot go into the details here, but we found that their present type of furnace is very wasteful. Their furnaces are simply holes in the ground, and the juice is boiled in earthen pans. There is no under-draught. With their best types of furnace we found that they used 6½ maunds of wood in making 1 maund of *gur*, though dried palm leaves gave much better results. Taking wood at 2½ annas per maund, this would mean that each maund of *gur* requires R. 1 worth of wood fuel for its preparation. We also tested a furnace of our own construction in which we burnt our wood on fire-bars and so had efficient under-draught. The furnace had a small chimney, and we used a shallow iron pan to boil the juice in. This furnace only required 5 maunds of wood to make 1 maund of *gur*. At 2½ annas per maund this wood would cost 12½ annas, a saving

of 3½ annas per maund of *gur* over the country method of *gur* making. It is therefore obvious that something can be done in the way of saving of fuel.

There is the possibility that in some districts coal would be a cheaper source of fuel than wood. We tried numerous experiments with coal, and our most favourable experiments showed that 1 maund of coal was equal to 2½ or 3 maunds of wood. It seems to me therefore that there are many places where coal would be a cheaper fuel than wood.

We now turn to the question of improving the colour of *gur*.

Anyone acquainted with the native methods of cane *gur* and palm *gur* production is at once struck by the characteristic dark colour of palm *gur*. There is no doubt that this dark colour stands in the way of popularity of palm *gur* to some extent. We have been able to determine the cause of this dark colour and to produce perfectly light-coloured *gurs*. We have found that fresh date palm juice contains an alkaline substance, *i.e.*, a substance which has the power of neutralizing acidity. When this is boiled up with sugars it decomposes them, forming black bodies. These black bodies are the cause of the dark colour of palm *gur*.

All one has to do therefore to produce light-coloured *gurs* is to add a small amount of acid to the palm juice before boiling it until the alkalinity is just destroyed. We have used citric acid, sulphuric acid, hydrochloric acid, alum which is acid, tamarind fruits, and lemon juice. With all these products we obtained light-coloured *gurs*.

The only question is whether there is a demand for these lighter coloured *gurs*. I have mentioned this piece of work, as I think it worthy of record here.

There is one other matter I would like to refer to. It deals with the improvement of the local industry of refining *gur*. About 15 lakhs worth of partially refined sugar known as *akrah* was produced in Jessore district in the season 1900-01. All this sugar is made by the country process of refining with water weeds. The *gur* is put in baskets and the liquid portion or molasses allowed to drain away below into an earthen vessel. A layer of water weed is

put on to the surface of the *gur* and after a few days' interval the top few inches of sugar is fairly white. It is scraped off and spread in the sun to dry and the water weed replaced. After a few days more, more sugar is scraped off and the process repeated until all the sugar has been refined. By this method it takes two to three weeks to refine a given portion of *gur*. Thus much capital is locked up, to say nothing of the amount of sugar which is lost by fermentation during the process. I have often thought that this country process could be superseded with great advantage by the use of centrifugals.

I had better perhaps explain the process of refining by means of centrifugals. The *gur* consists of a mass of crystals of sugar mixed up with the brown liquid portion called the molasses. The process of refining has for its object the separation of these two. A centrifugal is a big metal cup inside which is a smaller copper cup called a basket, whose sides are riddled with holes. The *gur* is broken up and put in the inner cup or basket and this is then made to revolve at a very rapid rate, usually at about 1,000 to 1,200 revolutions per minute. For this purpose we may use either an oil-engine or steam-engine. The liquid molasses are thrown through the holes in the sides of the basket, while the white sugar crystals are left behind. The whole process of separating takes 20 to 30 minutes as against two to three weeks by the native process.

I have, however, been told by the proprietors of these refineries that the centrifugal would not work with their *gur*. Through the kindness of the Manager of the Tarpur Sugar Works, Mr. N. Dutt, some tests were carried out in their centrifugals. No difficulty whatever was found in producing a good sugar direct from the *gur*.

The striking fact was, however, that ordinary *gur* made in the cultivator's fashion produced 31 seers of sugar from 2 maunds 17 seers of *gur* or a yield of 31 per cent.

Some *gur*, which had been made from juice which was collected in limed pots, gave 23½ seers of sugar from 1 maund of *gur* or a return of more than 58 per cent. This is a striking demonstration of the effect of the liming process in improving the quality of the *gur*. But I hardly think liming would have such a marked effect as this

very often. I should say this result must be considered as exceptional.

The sugar from the limed *gur*, moreover, was much whiter than that from the ordinary *gur*, and it was very much praised by the owners of refineries in Kotchandpur. The molasses which had been separated could of course again be boiled to *gur* and a second crop of sugar, obtained by a similar process.

I have endeavoured to give in as few words and in as simple language as possible an account of the practical side of my work in the palm sugar industry. More detailed information will be seen when the results are sent to the press, as I hope they will be shortly.

Notes.

THE EFFECT OF GROWING RADISHES ON THE SUCCEEDING MAIZE CROP.

On the Dacca farm in the past season maize was sown on a certain field. The crop on half of this field was quite a fair one. On the other portion of the field practically no crop was obtained, the plants being only six inches to one foot in height. They, however, gave a few badly formed small cobs. The whole field appeared to be pretty even. The marked difference in the maize crop on the two portions of the field seemed to be directly traceable to the fact that the portion which gave such a poor crop had had radishes growing on it in the previous cold weather.

Radishes are well known to be an exhausting crop, but in this case the effect was wonderfully marked. Samples of soil from the two portions of the field were taken and submitted to analysis for 'available' phosphoric acid and potash in the surface and sub-soil. The results are appended.

	Radish portion		No radishes	
	surface 6"	subsoil 6"	surface 6"	subsoil 6"
Available K_2O % ...	0·0083	0·0100	0·0092	0·0102
P_2O_5 %	0·0043	0·0021	0·0042	0·0027

It would thus seem that there are not sufficient differences in the 'available' K_2O and P_2O_5 figures to account for the effect. At the same time it must be remembered that these samples were taken after the growth of the maize. Possibly there may have been more 'available' P_2O_5 or K_2O in the plot on which no radishes

had been grown before the growth of the maize than in the other plot and the crop may have just used up this excess amount. Of course there are many other factors which might account for the difference observed, but owing to the transfer of the writer from Dacca the subject has had to be dropped and the matter is simply set out here as it is considered an observation worthy of record.—[H. E. ANNETT.]

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THE PRODUCTION OF ALKALOIDS AS AFFECTED BY THE WAR.

THE *Journal of the Society of Chemical Industry* of the 31st July last, which has just reached us, contains the report of the proceedings of the thirty-fifth annual meeting of the Society, held in Edinburgh on the 19th July and subsequent dates.

Some of the papers dealt with the influence of the European war on various chemical industries.

Mr. D. B. Dott showed how the production of alkaloids has been affected. During the early days of the war, alkaloids, and fine chemicals, which were mainly German products, found their way into the United Kingdom through the neutral countries. Now that Germany has been efficiently isolated, such indirect importation has been reduced to a minimum, and we are now mainly dependent on what is produced within the Empire or what can be imported from allied or friendly countries. The increased demand, due to the exclusion of Germany as a source of supply and to the medical requirements of the Army, has caused a very great increase in the price of alkaloids. There has been a rise from 63 per cent to 700 per cent in the course of two years, the average increase of price in the case of eight of the more important alkaloids being 237 per cent. This increase in the demand has caused a great increase in the output of those articles which British manufacturers were already producing.

Although for a long time opium alkaloids and quinine and lately caffeine, strychnine, emetine, and veratrine are being produced in Britain, larger amounts of all these bases (except morphine) were being made in Germany, and as regards atropine and most of the rarer alkaloids, the preparation has been almost entirely in German

hands. Atropine has scarcely been made in Britain and belladona root is scarce and dear. Indian and Egyptian samples of *Hyoscyamus muticus* might perhaps be utilized for the preparation of this alkaloid and of hyoscyamine if a sufficient supply of the raw drug could be ensured. Mr. J. H. Barnes analysed a sample of Indian *Hyoscyamus* and found that the dried plants contained the very high amount of 0·827 per cent of mydriatic alkaloids (*Agricultural Journal of India*, volume XI, page 86).

In the majority of cases, however, there is not much difficulty as to the supply of the proper raw materials. There is no scarcity of cinchona bark, or of nux vomica, or of opium. The reasons why the British manufacture of alkaloids is not attaining the proportions we would like it to reach are due to other causes. One is that there has been a very high rise in cost of freights owing to the war. Again many of the necessary solvents have also undergone large enhancements of prices, the Government having commandeered or limited the supply of these. At the present moment, manufacturers are fully engaged in meeting the increased demand for their standard products, and cannot afford to embark on new projects with a reduced staff and a limited supply of labour. There is, however, every reason to believe that in the near future many compounds which have so long had to be imported will be prepared in British factories.

As to the suggestion about growing medicinal plants in the British Isles, the climate and soil seem to be unsuited for the cultivation of the majority of the alkaloid-yielding plants.

It has also been suggested that now that the prices of alkaloids are very high, attempts should be made to produce these artificially in the laboratory. The difficulties, however, are enormous. The constitution of the majority of the alkaloids is very complex. Notwithstanding much elaborate and ingenious research, the synthesis of the two most important alkaloids, morphine and quinine, still remains unaccomplished. Even as regards those bases whose synthesis has been accomplished, there are difficulties connected with the complexity or financial inefficiency of the published methods.

But while the synthetic preparation of the natural alkaloids has not been of much practical use, important results have been obtained in the discovery of artificial substitutes having a comparable if not equal pharmacological value. Thus "euphthalmine" possessing a strong mydriatic action is used as a substitute for atropine. The synthetic compounds known as "eucaines" are being substituted for cocaine to produce local anaesthesia. Mention may also be made here of the synthetic anaesthetic which is proving of most general value, *viz.*, "novocaine."

Thus one effect of the war is to act as an indirect stimulus to the production of artificial alkaloids.—[J. SEN.]

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WE note in the annual report of the British Cotton Growing Association ending 31st December, 1915, the following reference in report of work in the Colonies.

"Representations were made to the Association by Mr. C. H. Townsend, the Director of Agriculture and Industries for Punjab, Lahore, on behalf of the Punjab Government, regarding an agreement which had been entered into with the International Federation for a lease of 7,500 acres in the Montgomery district of the Punjab province, to be irrigated by the new Lower Bari Doab canal. It was proposed to cultivate cotton, wheat and other crops, and to grow American cotton, and when the Estate is fully developed, the crop is expected to reach at a low estimate 600 to 700 bales. Owing to the war this agreement had to be cancelled. The scheme was fully considered by the Council, but in view of the fact that the proposals involved a capital expenditure of about £35,000 and as the estimated production of cotton was relatively small, the scheme did not appear very attractive from a business point of view, except as an experiment for future developments. The financial position of the Association did not permit the Council taking up the scheme, but in refusing the offer they stated that they would be only too glad to help the Government in their attempts to improve the quality of Indian cotton as far as the financial position of the Association would allow."

DEVELOPMENT OF RUBBER CULTIVATION IN BURMA.

As a result of discussion at the beginning of the year between the Lieutenant-Governor of Burma and representatives of the Lower Burma Planters' Association, the rules regulating grants and assessment of land for rubber cultivation in Burma have been considerably modified. The rubber planters represented that the extension of rubber growing was being hindered by the liability of rubber estates leased under the rules then in force in Lower Burma to a land revenue assessment which might rise to as much as Rs. 25 an acre. Accordingly, a revision of the rules was agreed to, providing for the issue of grants instead of leases, and the levy of royalty on the net value of rubber, combined with a moderate revenue assessment, instead of the previous liability to land revenue, the rates of assessment to be reconsidered every 20 years. A committee consisting of the Financial Commissioner of Burma and representatives of the Lower Burma Planters' Association drafted these new regulations, which were accepted by the Lieutenant-Governor and duly promulgated. Their recommendations included the following:—Land for rubber cultivation to be granted in perpetuity, subject to payment of the annual land revenue assessment and the royalty on the net value of rubber produced and exported; exemption from land revenue, to be granted for the first eight years of occupation; land revenue and royalty to be levied at the rate of Rs. 3 per acre and 2 per cent respectively for 20 years; grants to prescribe that one-tenth of the total area granted must be planted with rubber trees within two years of the grant, one-half within four years, and three-fourths within eight years. The new rules affect only land granted for rubber cultivation on and after July 1st, 1916; for land granted or leased under previous rules certain abatements of royalty and land revenue assessments are allowed, and owners are offered the opportunity of surrendering their land at any time in the next ten years, and of taking out a grant under the new rules. The following table shows the area under rubber cultivation in Burma and the amount exported in the past five years, as given in the

Report on the Maritime Trade and Customs Administration of Burma :—

Year	Acres	Lb.
1911-12	32,772	310,240
1912-13	44,029	526,176
1913-14	50,946	765,072
1914-15	57,785	987,392
1915-16	57,843	1,285,984

Experience shows that large areas in Burma are suitable for rubber cultivation, and the committee considers that an estate in full bearing should yield not less than 350 to 400 lb. of rubber per acre.—(*The Economist*, London, August 19th, 1916.)

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DENATURED SPIRIT OF ALCOHOL.

THE Russian Ministry of Finance, according to a message from Reuter, reports the *Indian Trade Journal* is organizing an international competition, with prizes ranging up to £3,000, for methods of rendering methylated spirits and similar harmful liquids absolutely undrinkable. A second competition is being arranged, with prizes up to £7,500, for new or improved methods of utilizing alcohol for combustible or other purposes. The total rewards will amount to nearly £68,000.

Mr. Hamel Smith urges that tropical planters and others in all parts of the world should take an interest in this contest, and try to induce their respective Governments to do the same, as the enormous amount of raw material that is made available every year from the waste products of the Manila fibre, banana, coconut sugar, cacao, and other industries would allow an output of alcohol suitable for fuel and other purposes sufficient to enable the British Empire and her Allies to be independent of unfriendly nations for their supply of spirit for such purposes. Like Pears' soap baby, we shall not be happy until we have induced the authorities and the planters to combine and put these valuable by-products to so good a use.

Denatured alcohol is simply alcohol which has been so treated as to spoil it for use as a beverage or medicine, and prevent its use

in any manner except for industrial purposes. Denaturing can be accomplished in many ways. In England a mixture suitable for industrial purposes, but unfit for any other use, is made by mixing 90 per cent of ethyl alcohol (alcohol made from grain, potatoes, beets, etc.), with 10 per cent of methyl or "wood alcohol." In Germany some of the other denaturants are camphor, chloroform, iodoform, ethyl bromide, benzine, castor oil, etc. In a very interesting work on the subject by F. B. Wright, U. S. A., full details are given as to the various methods of producing the desired results, and mention is made of the uses to which denatured alcohol may be put. For instance, he says it is a safe fuel. Although it has only about half the heating power of kerosene or gasoline, gallon for gallon, yet it has many valuable properties which may enable it to compete successfully in spite of its lower fuel value. In the first place, it is very much safer. Alcohol has a tendency to simply heat the surrounding vapours and produce currents of hot gases which are not usually brought to high enough temperature to inflame articles at a distance. It can be easily diluted with water, and when so diluted, no more than one-half, it ceases to be inflammable. Hence, it may readily be extinguished, while burning gasoline, by floating on the water, simply spreads its flame when water is applied to it.

When alcohol is used for lighting purposes, the general estimate of its value gives it about double the power of kerosene, a gallon of alcohol lasting as long as two gallons of the oil. When used for street lighting, alcohol vapour burns like gas with an incandescent flame in a hooded flame covered by a Welsbach mantle. This light rivals the arc light in brilliancy, and requires to be shaded to adapt it to the endurance of the human eye. Alcohol can also be employed in the same manner as gas in cooking stoves.

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A BUSHEL of maize (56 lb.) would yield about 5 U. S. gallons of proof spirit, or 2½ gallons of absolute alcohol. One gallon of molasses would yield about four-tenths of a gallon of alcohol. One bushel of sweet potatoes (54 lb.) would give about half a gallon of

absolute alcohol, and ordinary potatoes might be expected to give a similar quantity.

Mr. Brünnich said that another excellent article very largely used in America was cassava (arrowroot), which was known to yield very heavy crops in some parts of Queensland, and this would give about the same amount of alcohol as sweet potatoes.

The Agricultural Chemist pointed out that alcohol could be used for driving gas engines for ordinary running, but it had not been found suitable for running motor-cars, as it had not the flexibility of petrol, such as is required for frequent starting, and running at slow speed. The difficulty was reported to have been overcome in Germany by the addition of a certain amount of benzol (benzene), which was a by-product of coal distillation, and which could be produced in this country. Alcohol, however, could be used in certain classes of lamps, and it was one of the cheapest of fuels and sources of light.

A secondary product of alcohol was acetic acid, which was also in very short supply. Mr. Brünnich suggested spoiled pine-apples and apples as sources of supply.—(*The Queensland Agricultural Journal*, July, 1916.)

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THE VALUE OF HUMOGEN.

In its last April issue the *Mark Lane Express* had the following note regarding this fertilizer.

"Humogen is the name given to the preparation of bacterized peat invented by Professor Bottomley, and such glowing accounts have been given of the fertilizing value of the substance that much attention has been drawn to it. Perhaps it is a pity that the preparation should have been so "boomed," because the effect has been to raise great expectations in some quarters, and if those sanguine hopes are not fully realized a reaction will set in, and the possible value of the substance may not be fairly realized.

"During this season, it will be on its trial, and we hope the verdict at harvest time will be in its favour. If so, a new home industry of economic importance will be opened up, and agriculturists

will have the benefit to be derived from a cheap and powerful fertilizer.

"At present it does not seem possible to express a definite opinion as to its value. A recent report on the subject from the Midland Agricultural and Dairy College is certainly not encouraging. According to this report bacterized peat is sent out in two forms, *viz*: (1) as a fibrous material for incorporating with the soil, and (2) as a powder for top dressing.

"The powder was applied as a top dressing to wheat and 'seeds' hay at the rate of 7 cwt. per acre, but produced no result whatever on either crop.

"The fibre was tested with potatoes, 5 cwt. per acre being used. The results were again entirely negative."

In this connection it will be interesting to note that experiments have already been conducted with this substance at Woburn during 1914 and 1915. *The Journal of the Royal Agricultural Society of England* for the year 1914 contains a long account of the work done with 'humogen.' The experiments of 1915 are also described in the same Journal, vol. 76. The following conclusions have been arrived at:—

"Under conditions such as those obtaining in green-house cultivation and where plants can be regularly watered and tended, a good preparation of humogen may produce a very marked increase in the growth of the green parts of plants and in the growing of green crops, but it will show practically no benefit in the production of grain.

"Under natural conditions of crops growing in the open, it has not as yet been established that, as regards the ordinary corn crops of the farm, any advantage is likely to accrue from the use of humogen when used in quantity, such as a farmer is likely to be able to afford."

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A GERMAN SUBSTITUTE FOR JUTE.

THREE specimens of the substitute for jute employed by the Germans in the manufacture of their war sacks have arrived in Calcutta from the captured German trenches near Pozieres. The

material is a "textilose" made from paper pulp which has been passed through machines and spun into thread or cord preparatory to being woven into a tough cloth. The fragments of bag, which are very much soiled by exposure to weather and gunfire, were originally grey in colour. They were subjected in Dundee to six weeks' saturation with water. The effect was practically *nil.* The material has great powers of resistance and, apart from the fact that the finished textilose sacks must cost considerably more than jute sacks, is in every way a creditable substitute for the Bengal natural fibre. It is understood that the Indian Government has made application for specimens. Those alluded to above were brought to Calcutta by private agency.—(*Statesman*, August 26th, 1916.)

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WALL PAPERS THAT DESTROY LIGHT.

PEOPLE are constantly asking what is the best colour for wall paper or hangings. The following table will give the fullest particulars. Common wall papers were tested recently in an illuminating laboratory for their light-absorbing qualities, with the following results :—

Wall papers	Percentage of light absorbed
White	30
Chrome yellow	38
Orange	50
Plain deal	55
Yellow	60
Light pink	64
Emerald green	82
Dark brown	87
Vermilion	88
Blue-green	88
Cobalt-blue	88
Deep chocolate	96

This table shows that, if a room papered with dark green be repapered with chrome yellow, it will be four times as light with the same lamps and windows. In many cases householders pay too much for electricity and gas lighting, because their light-absorbing

wall coverings destroy the light rays.—(*Journal of the Department of Agriculture, Victoria*, July, 1916.)

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MATKEE—A GREEN-MANURING PLANT.

We extract the following note from a paper sent us by Mr. Amolak Ram of Palampur. It deals with the use of a common weed—*matkee*—for green-manuring of tea estates. The author says :—

" A common weed found in jungles, tea gardens and rice fields, etc., locally known as " Matkee " (*Æschynomene indica*, L.) is very useful for green-manuring in this valley. It is an annual weed of leguminous order, having a round stem of erect or creeping nature. Stipulated compound leaves attached to the stem with a short stalk. Bisexual flowers of yellow colour. Calyx is composed of five sepals. Corolla having five petals. Stamens are ten in number.



Roots of a " Matkee." Plant

(1) *Points in favour of growing matkee.* It is a plant of leguminous order and will fix nitrogen in the soil with the help of nitrogen-fixing bacteria.

(2) It is of rapid growth.

(3) If *matkee* of spreading nature is grown, which I prefer, it will greatly help in checking the growth of other weeds and useless grasses which hinder the growth of tea bushes.

(4) It will not shade the tea bush, so it does not in any way hinder the leaf-producing power of the tea plant, in its growing season.

(5) It will make use of the plant food which is usually washed away during rains and restore it to the field when the crop is ploughed in.

(6) Being a common weed in this valley it will grow well without any trouble.

(7) Seeds should be sown in the end of May and the crop buried in August (when it is in flower) with the rain hoeings."

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

THE Fourth Annual Meeting of the Indian Science Congress will be held at Bangalore on the 10th, 11th, 12th, and 13th January, 1917. H. H. the Maharaja of Mysore has consented to be Patron of the meeting whilst Sir Alfred Bourne, K.C.I.E., F.R.S., will be the President. The following Sectional Presidents have been appointed :—Mr. J. MacKenna, I.C.S. (Pusa), Agriculture and Applied Chemistry; the Rev. D. Mackichan (Bombay), Physics; Dr. Ziauddin Ahmad, C.I.E. (Aligarh), Mathematics; Mr. K. Ramunni Menon (Madras), Zoology; Mr. C. S. Middlemiss, C.I.E. (Calcutta), Geology; Dr. J. L. Simonsen (Madras), Chemistry.

MEETINGS OF MYCOLOGISTS AND ENTOMOLOGISTS will be held at Pusa on the 5th of February, 1917, and following days It is expected that they will be attended by representatives from all Provinces and from the Indian Tea Association, etc.

SIR THOMAS HOLLAND and the members of the Indian Industrial Commission visited Pusa on the 23rd November, 1916, from Muzaffarpur. They inspected the Laboratories and the Institute and the work in progress on various scientific researches connected with Industries.

THE HON'BLE MR. CLAUDE HILL, C.S.I., C.I.E., I.C.S., Member in charge, Revenue and Agriculture Department of the Government of India, visited Pusa from the 29th November to the 4th December last.

MR. J. N. SEN, M.A., F.C.S., Supernumerary Agricultural Chemist (at present Offg. Imperial Agricultural Chemist), and Mr. Wynne

Sayer, B.A., Assistant to the Agricultural Adviser to the Government of India, have been confirmed in the Indian Agricultural Service, with effect from the 9th February, 1917, and the 20th March, 1917, respectively.

MR. ROGER THOMAS, B.Sc., has been confirmed as Deputy Director of Agriculture in the Agricultural Department, Madras, with effect from 7th November, 1916.

IN consequence of the deputation of Mr. D. T. Chadwick, I.C.S., Director of Agriculture, to Russia, Mr. G. A. D. Stuart, I.C.S., has been appointed to act as Director of Agriculture, Madras.

MR. G. MILNE, I.C.S., Director of Agriculture, Bihar and Orissa, has returned from privilege leave and resumed charge of his duties.

MR. T. COUPER, I.C.S., has been appointed to officiate as Director of Agriculture, Burma, in place of Mr. H. Clayton, I.C.S., who officiates as Registrar under Section 3 of the Co-operative Societies Act, 1912.

MR. E. THOMPSTONE, Deputy Director of Agriculture, Northern Circle, Burma, has been granted by His Majesty's Secretary of State for India an extension of furlough for two months in continuation of the combined leave granted to him.

MR. A. L. SHEATHER, B.Sc., M.R.C.V.S., has been appointed to the Imperial Bacteriological Laboratory, Muktesar, as Imperial Bacteriologist, with effect from the forenoon of the 4th October, 1916.

THE services of Mr. C. W. Wilson, M.R.C.V.S., Second Superintendent, C. V. D., United Provinces, have been placed at the disposal of the Hon'ble the Chief Commissioner, Central Provinces, for employment as Superintendent, Civil Veterinary Department, Central Provinces.

THE services of Mr. S. G. M. Hickey, M.R.C.V.S., Offg. Superintendent, C. V. D., Central Provinces, have been placed at the disposal of the Government of the United Provinces for employment as Second Superintendent, Civil Veterinary Department, United Provinces.

MR. A. W. FREMANTLE, of the Indian Agricultural Service, on return from leave, will be posted as special officer in charge of ravine reclamation work with headquarters at Etawah.

THE following officers have been confirmed in the Civil Veterinary Department with effect from the dates noted respectively against each :—

Mr. J. G. Cattell, M.R.C.V.S., Superintendent, Civil Veterinary Department, Sind, Baluchistan, and Rajputana	27th November, 1913.
Mr. P. J. Kerr, M.R.C.V.S. (on Military duty) ...	22nd January, 1916.
Mr. D. Meadows, M.R.C.V.S., Superintendent, Civil Veterinary Department, North Punjab and North-West Frontier Province	3rd November, 1916.

THE APPOINTMENT OF A SOIL PHYSICIST IN BOMBAY.—There are large areas in the Bombay Presidency which receive scanty rainfall and which have no irrigation facilities. The application to these areas of dry-farming methods which have been found successful in the United States of America and other arid tracts is engaging the attention of the Local Department of Agriculture. But the work is hampered for want of proper knowledge of the nature and physical composition of the various soils, their capacity for taking up moisture, their capillary power and the extent to which they lose moisture by filtration or evaporation. It is therefore proposed to undertake a survey of the soils of the Presidency with special reference to their geological formation and a systematic study of soil physics supplemented by chemical analysis as far as possible. The Secretary of State has sanctioned for this purpose the post of a Soil Physicist in the cadre of the Imperial Agricultural Service in the Bombay Presidency. The appointment will not however be filled up until the financial conditions of Government materially improve.

SINCE the publication of the list in the last issue of this Journal, the services of the following officers have been placed temporarily at the disposal of the Government of India in the Army Department:—

No.	Name	Designation
*1.	Dr. G. H. K. Macalister, M.A., B.SC., M.D., D.P.H., M.R.C.S., L.R.C.P.	Pathologist, Imperial Bacteriological Laboratory, Muktesar.
2	G. C. Sherrard, B.A. ..	2nd Deputy Director of Agriculture, Bihar and Orissa.
3.	J. H. Ritchie, M.A., B.SC. .	Deputy Director of Agriculture, Central Provinces.
4.	T. Gilbert, B.A. ..	Deputy Director of Agriculture, Southern Division, Bombay.
5.	G. Clarke, F.I.C. ..	Agricultural Chemist, United Provinces. (Got a commission in the Royal Artillery in England.)
6	K. Hewlett, M.R.C.V.S. .	Principal and Professor of Veterinary Science, Bombay Veterinary College (on military duty for all Veterinary services connected with Bombay in addition to his own duties).

THE eight Indian Assistants who went to Mesopotamia in connection with the campaign for the extermination of "Flies" have now returned to Pusa on completion of their military duties.

Reviews.

Sulphitation in White Sugar Manufacture.- By FRANCIS MAXWELL, Ph.D., A.M.I.Mech.E., F.C.S. Norman Rodger, St. Dunstan's Hill, London, E.C., 1916. Price 7/6 net.

THE appearance of a technical monograph on one of the most important processes in the manufacture of refined sugar is to be welcomed more particularly at the present time, when the war with the central powers of Europe has shut off one of the great competitors to the cane sugar industry, and so given the latest comers in the sugar trade a chance of establishing themselves under more favourable conditions than existed in the spring of 1914. Like many of the comparatively simple chemical processes in use in the manufactures and arts the use of compounds of sulphur as purifying agents in the refining of sugar has been in operation in one form or another for very many years, and dates as far back as 1792 when Achard, the founder of the beet sugar industry, first applied a diluted solution of sulphuric acid to beet juice with a view to precipitating undesirable organic compound, especially albuminoids, the free acid being subsequently neutralized by the addition of chalk before the juice was heated.

The author of this work commences with a short history of the application of sulphurous acid to sugar refining which will be interesting to students of the chemistry of sugar making, as well as to the manufacturer. The utility of the book would be materially enhanced if the author had given, in addition to the historical preface, a more detailed bibliography of the chemical researches bearing on this most important chemical process, and of the many patents relating to it. The arrangement of the book includes first a description of the preparation and properties of sulphur dioxide and its

use in the sugar refinery together with a description of the various types of apparatus used and the analytical method of controlling the process (Chapters I to IV); secondly, a dissertation on the action of the sulphurous acid (Chapter VI), and the principles of its application (Chapters VII and VIII); and thirdly, a description of the process in practice as at present adopted in some of the principal cane-growing countries. Finally the book contains a useful summary of the text in the form of simple questions and answers.

No mention is made of the sulphitation process as practised in Louisiana. As this is one of the simplest of the sulphitation processes and as the Louisiana cane juice is similar in composition to that derived from the greater part of the cane of India, this is a serious omission. A detailed account should have been included of Harloff's acid thin juice process.

The practical value of the book is evident throughout and indicates clearly that the author is himself closely in touch with the details of the process. For instance, he draws attention to the necessity in humid tropical countries of using dry air in the combustion of the sulphur, an important practical point often ignored and which leads to endless mechanical troubles in the factory in consequence. The merits and demerits of sulphitation before and after tempering with lime are discussed and even in heavy and impure juices the author considers that sulphitation after liming is preferable to the reverse process. Treatment of the mill juice with sulphurous acid results in the precipitation of organic impurities and partial decolorization. In the subsequent neutralization of the acid juice a considerable portion of the organic precipitate is re-dissolved causing the juice to re-assume its original dark colour and so negates in part the action of the sulphurous acid. If sulphitation before liming is carried out arrangements should be made to remove the precipitate formed by the addition of the sulphur dioxide as far as possible before adding the lime. This is done in some cases in Mauritius with excellent results. The method adopted there is to pass the juice after adding the sulphur dioxide through a long shallow tank termed a " bac portal "—divided into a number of compartments—which accelerates the settling of the precipitate.

This chapter of the book will be read with interest by sugar makers in India who have to deal with hard cane yielding impure juice.

The arrangement of the book would be improved if the description of the analytical methods of chemical control were collected into one separate chapter instead of remaining scattered throughout the text.

We recommend the book to Indian sugar manufacturers and others interested in the Indian sugar industry.—[J. H. B.]

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A Handbook for Cane-Sugar Manufacturers and their Chemists.—By GUILFORD L. SPENCER, D.Sc., Chief Chemist to the Cuban-American Sugar Company. Fifth Edition, partially Rewritten and Enlarged, 1916. New York: John Wiley & Sons; London: Chapman & Hall. Price $3-50.

THE issue of a new edition of this excellent publication will be welcomed by cane-sugar manufacturers and their chemists throughout the world. The book has been largely rewritten and the chemical section revised to meet the conditions of the very large factories now in operation. The section devoted to the description of sugar manufacture has been greatly enlarged in this edition, and now includes a very full description of the various modern processes in use in the manufacture of raw and refined sugar. Among the useful and modern features of this edition may be mentioned the fairly full series of references to authors and papers given throughout the text, which renders the work especially valuable to the expert. The inclusion of Lippmann's index table of the various substances which have been used for clarifying sugar solutions is an instance of the improvements effected in this edition. We should like to see included in a practical handbook of this nature a chapter on sugar machinery patents and a short tabulated statement of the principal patents of the more modern processes and the machinery used in them. In this connection we note with regret the omission of any account of the Kestner climbing film evaporator—one of the most modern and efficient forms of evaporating machinery. Some of the chapters of the fourth edition have been re-inserted in

the new one without any addition or modification. This is especially noticeable in the article on fermentation. In view of the importance of this subject to the sugar manufacturer it is especially desirable to include a more extensive and scientific account of the various fermentation processes which affect the material used and the products made in the sugar factory and we hope that these omissions will be rectified in the next edition of this excellent handbook. Though the fifth edition has increased the book by two hundred pages, the use of India paper and a flexible leather cover has actually reduced its size which enables it to be conveniently carried in the pocket. We recommend all our readers who are interested in the Indian cane industry to possess themselves of a copy of this new edition without delay.—[J. H. B.]

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A Second Edition of the Note-Book of Agricultural Facts and Figures, by Mr. R. C. Wood, M.A., Principal of the Agricultural College, Coimbatore, has been issued. The book is modelled very closely on McConnell's famous Agricultural Note-book and has been found useful by those engaged in agricultural investigation, instruction, or demonstration in South India. Its first edition was reviewed in this Journal, vol. X, part IV, October, 1915. In the present edition the opportunity of making a few minor corrections and certain additions has been taken among which we notice an index which the writer hopes will add to the usefulness of the book. The price is R. 1 or 1*s*. 6*d*.—[Editor.]

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Notes on Improved Methods of Cane Cultivation.—By G. CLARKE, F.I.C., and NAIB HUSAIN. Bulletin No. 35 of the Department of Land Records and Agriculture, United Provinces. Printed at the Government Press, Allahabad. Price 1 anna.

IN view of the importance of the cane-sugar industry in the United Provinces which have about a million and a quarter acres under the crop—over half of the total acreage under sugarcane in India—we have much pleasure in reviewing this small brochure and thereby drawing attention to the immense possibilities that are

opened out for the improvement of this industry in the Rohilkhand Division where the soil and climatic conditions are, it is well known, favourable to cane cultivation. Mr. Clarke, Agricultural Chemist to the Government of the United Provinces, has devoted himself to a study of this crop for several years and has already written several original articles and bulletins on sugar and sugarcane which are well known to the readers of this Journal. The present bulletin records the results of the investigations carried out at Shahjahanpur Sugarcane Research Station during the last four years whereby the Department is now in a position, despite the locality being outside the "Sugar belt," definitely to recommend two varieties of improved sugarcane, *viz.*, Ashy Mauritius and J. 33, to the cultivators of the Rohilkhand Division. It has been demonstrated that two things are necessary to increase the yield of sugar per acre in Northern India—(1) improved varieties, and (2) improved methods of cultivation. One is useless without the other.

Ashy Mauritius is a thick cane of the *Paunda* type and yields a very excellent quality of *gur* and a very crystalline *rab* giving 100 to 120 mds. of *rab* per acre according to the season. It cannot be grown without trenching.

J. 33 is a medium thick cane obtained by hybridization. It resembles in many morphological characters one of its parents, *Chuni*, the thin indigenous cane of the Rohilkhand Division. It fully matures during the short growing period of Upper India.

To secure the maximum yield of sugar and the maximum profit, improved methods of cultivation, irrigation, and liberal manuring are required. While these improved canes respond very well to intensive cultivation the *deshi* varieties do not. Under the same intensive treatment while Ashy Mauritius and J. 33 yielded 105 and 84 maunds of sugar per acre *Reora*, one of the best of the provincial canes, gave only 55 maunds. The bulletin gives a clear description of the trenching method, manuring, and irrigation required to produce the best results with these canes. It must be said that the method of trenching, etc., requires a certain amount of capital (which is however not large) and irrigation facilities. It is therefore suitable for those places in sugarcane districts where wells, tube-wells, and

pumping plant have been successfully installed. When one, however, looks to the yield of these improved canes averaging Rs. 350 to Rs. 450 per acre it will be clear that the increased outlay necessitated by this intensive cultivation is more than repaid.

When the amount of capital required for intensive cultivation of thick types of cane like Ashy Mauritius cannot be found, medium thick canes of the type of J. 33 can be grown without trenching if they are subsequently carefully cultivated and earthed up, and the bulletin gives clear instructions as to how to do it.

This cane does not stand the treatment ordinarily given to thin canes in some parts. At the Rosa factory the yield of this cane was some six to seven hundred maunds per acre.

It has long been recognized that for the improvement of the sugar industry in Northern India the introduction of medium sized cane in place of the small thin canes is essential. As J. 33 when properly cultivated is just the kind of cane required and as the Agricultural Departments are popularizing it among cultivators (some 3,000 maunds of this cane were distributed last year) we think there is a good future for this industry provided co-operative credit societies or some other agencies provide the cultivators with the money required for intensive cultivation, and also if co-operative manure societies help in making the requisite manures available to the cultivators. We hope that as the result of joint labours of the Agricultural and Co-operative Departments these improved varieties of cane and the improved methods of cultivation advocated by the Department will come into favour. It will mean a very great improvement in the economic position of the sugarcane cultivators and also improve the general outlook of this industry in the Province.—[Editor.]

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Some Wild Fodder Plants of the Bombay Presidency.—By Dr. BURNS and Messrs. BHIDE, KULKARNI, and HANMANTE. Bulletin No. 78 of the Department of Agriculture, Bombay. Printed at the Yeravda Prison Press, Poona. Price As. 13.

THIS Bulletin deals with some "Wild Fodder Plants of the Bombay Presidency" from the standpoint of economic value for

grazing and agriculture of these plants. Twenty-four grasses are dealt with, including 9 species of *Andropogon*, and 10 wild fodder plants including 3 Indigoferas. Most of the grasses have analyses attached showing the composition before and after flowering. This is an important point and little attention is usually paid to it in India when wild grass is being cut for hay. Many of the grasses have been tested in plots at the Ganeshkhind Gardens, Poona, and the yield of fodder noted. To facilitate identification of the plants and grasses mentioned in the bulletin a clear drawing of each specimen is attached. These plates enhance the value of the bulletin which will be of interest for reference to many people.—[G. S. H.]

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Hints for the Cultivation of Roses.—By H. J. DAVIES, F.R.H.S., Superintendent, Government Horticultural Gardens, Lucknow. Bulletin No. 36 of the Department of Land Records and Agriculture, United Provinces. Printed at the Government Press, Allahabad. Price 1 anna.

THIS is a very useful little publication and gives practical hints for the cultivation of roses both in the plains and hills of Northern India. Selection of soil, methods of planting, treatment of imported roses and manuring and selection of roses are the main headings under which the subject is dealt with. A rich loamy soil with a certain amount of clay but free from water-logging is recommended as the best for roses. Application of lime is said to have beneficial effects when the soil is of a retentive nature: it also tends to neutralize the injurious acids in soils which have been heavily manured. The author advises that the roots of the plant should not come in contact with manure directly after planting and warns us against the fatal effects of over-manuring. Practical recommendations regarding pruning, watering, and the measures to be adopted against insect pests increase the value of the pamphlet. It ends with a very useful list giving a selection of roses for planting in mixed beds, masses, for exhibition purposes, and as climbers for pergolas or arches. In our opinion the bulletin gives much useful information likely to help an amateur in the successful cultivation of roses.—[Editor.]

The After-War Settlement and Employment of Ex-Service Men in the Oversea Dominions.—Published for the Royal Colonial Institute, by the Saint Catherine Press, Stamford Street, London, S. E. Price Threepence net.

We have received from the Royal Colonial Institute a booklet giving the report of Sir Rider Haggard on his mission to the outlying parts of the British Empire in search of support for the scheme for placing the British soldiers, now fighting on the Continent, on the land in the British Empire after the War and so preventing the emigration to other countries which took place to such a large extent after our last great war—the South African—when some 123,000 men went to United States alone, despite the fact that there was ample room for them in the Empire, had arrangement only been made beforehand. The support accorded to Sir Rider Haggard appears to have been of a unanimous kind in all the Dominions except South Africa, where the coloured labour problem effectually prevents any such scheme being thought of for the present—and his mission received the cordial endorsement merited in all quarters. We quote one or two extracts from the booklet which may well be pondered by all who have the future welfare of the Empire at heart. They show that at last we have begun to look ahead and our famous policy of " muddle through " is altering for the better.

Thus the Queensland Government, while offering land, a million acres, for soldiers to settle on, say its offer is dependent on being able to raise the funds for the necessary railways and development. The Canadian Pacific Railway Company, Alberta, offer land, but stipulate *married* men with previous agricultural experience, as they propose to thoroughly prepare their farms before settlement. Such commonsense stipulations are enough to turn the hair of advocates of the Small Holders Act of the past, who forgot all these essentials and thought the land mattered more than the man—a fatal error. The case, as it now stands, may be summed up in this extract from the report :—

" I am, however, proud to reflect that although, for reasons which I have already stated, nothing can be expected from the Union of South Africa, and the letter from the Government of

New Zealand is less definite than those received from the various Governments in the other parts of the Empire, on the whole, your efforts may be considered to have met with considerable success. Indeed, I imagine, I shall scarcely be going too far if I repeat of the self-governing parts of the Empire at large the words of my cable to you about Australia—namely, that everywhere there is now an open door for the British ex-service man, who for the most part will be admitted on terms practically of equal advantage to those which they determine to accord to their own citizens. Wherever he may choose to settle he will, I am convinced, receive the warmest of welcomes and much the same assistance that each State or Dominion ultimately decides to give to its own returned soldiers. But on these points the letters speak for themselves, and from them you will draw your own conclusions.

"The rest is in his own hands. If he justifies the hospitality extended to him as a fellow-subject of the Crown who has fought for the common cause, he and his family can do well and possibly rise to affluence, whether he selects Rhodesia, Australia, New Zealand, or the vast and wealthy Dominion of Canada as his future home. If, however, he lacks character or shrinks from effort, success cannot be promised to him. In the end everything depends upon the man himself and, I may add, upon the man's wife."

And further on in the booklet we extract the following which shows the commonsenses actuating the whole proposal:—

"Look at the condition of affairs which will confront them (our soldiers) when they return to this country. In the first place there will be this great host of men—hundreds of thousands in number—possibly something between 1,000,000 and 2,000,000. They will come back to a country where it is almost certain that the labour market will be congested, where wages must fall, where the majority of people—because the conditions of the moment are quite artificial—will be much poorer than now. That is the whirl of competition into which they will be flung."

You cannot live on trade alone. The land breeds people which the cities eat—without the land everything will die. Therefore

the land is the most vital of all the problems with which we have to deal. Had the inclinations of those who hope to prevent emigration from the British Empire been acted on in the past, there would be no British Empire to-day, and the reflection we are left with after reading this booklet is much—very much of this is true of India, but to what extent is it realized yet.—[W. S.]

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1. Agriculture after the War, by A. D. Hall. Pp. vii + 137. London: John Murray, 1916. Price 3*s*. 6*d*. net.
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4. Organic Agricultural Chemistry. (The Chemistry of Plants and Animals.) A Text-book of General Agricultural Chemistry or Elementary Bio-Chemistry for use in Colleges, by Joseph Scudder Chamberlain. 8″ × 5¼″. Pp. xvii + 319. Macmillan Co. Price 7*s*. net.
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9. Evolution by Means of Hybridization, by J. P. Lotsy. 9¼″ × 6¼″. Pp. x + 166. The Hague: Martinus Nijhoff. Price 6*s*. net.

10. Modes of Research in Genetics, by Raymond Pearl, Biologist of the Maine Agricultural Experiment Station. Crown 8vo. London: Macmillan & Co., Ltd. Price 5*s*. 6*d*. net.
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13. Sulphitation in White Sugar Manufacture, by Francis Maxwell. London: Norman Rodger, St. Dunstan's Hill, London, E.C. Price 7*s*. 6*d*. net. Postage 4*d*. extra.
14. A Critical Revision of the Genus Eucalyptus, by J. H. Maiden. Vol. III, Part 7. Sydney: W. A. Gullick. Price 2*s*. 6*d*.
15. The Economic Life of a Bengal District, A Study, by J. C. Jack, I.C.S. Pp. 158. Oxford: Clarendon Press. London: Milford. Price 7*s*. 6*d*. net.

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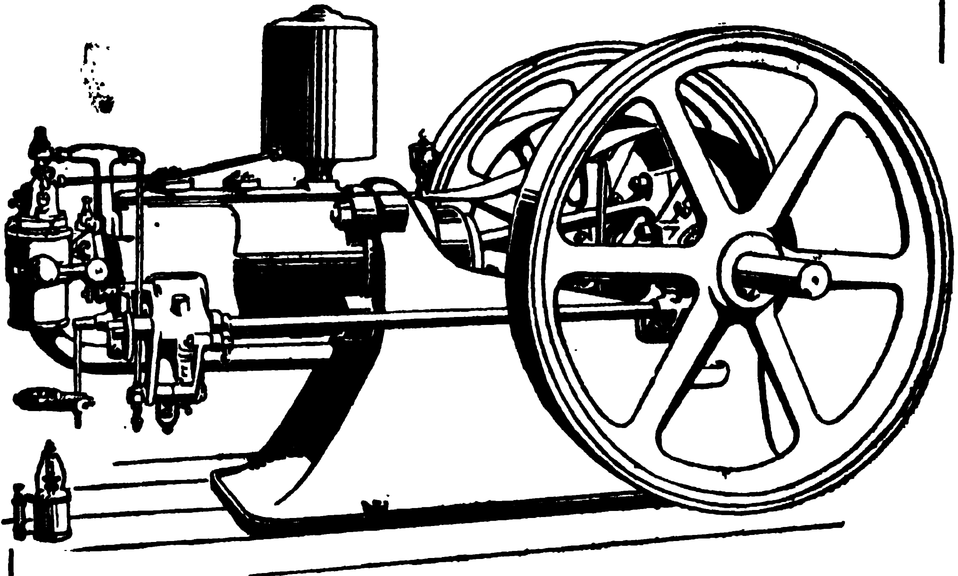
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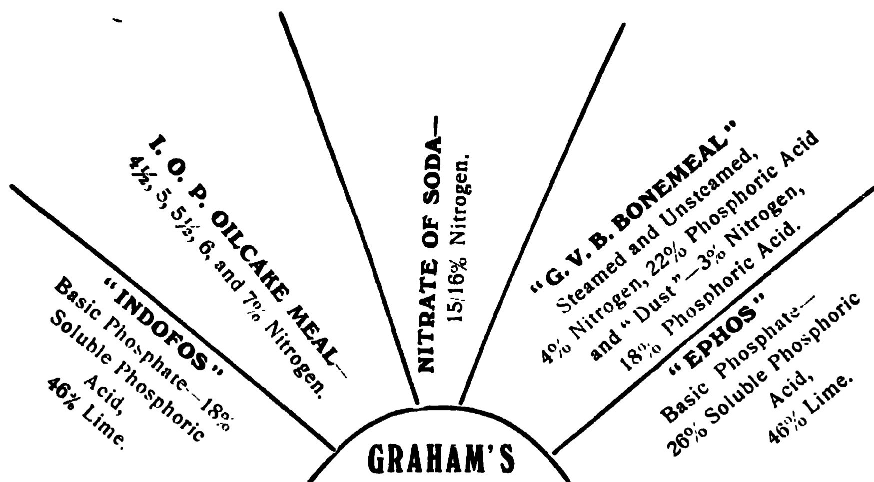
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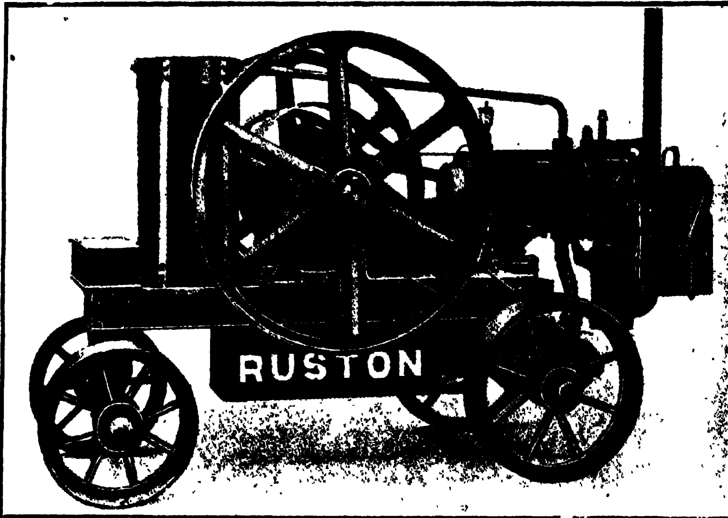
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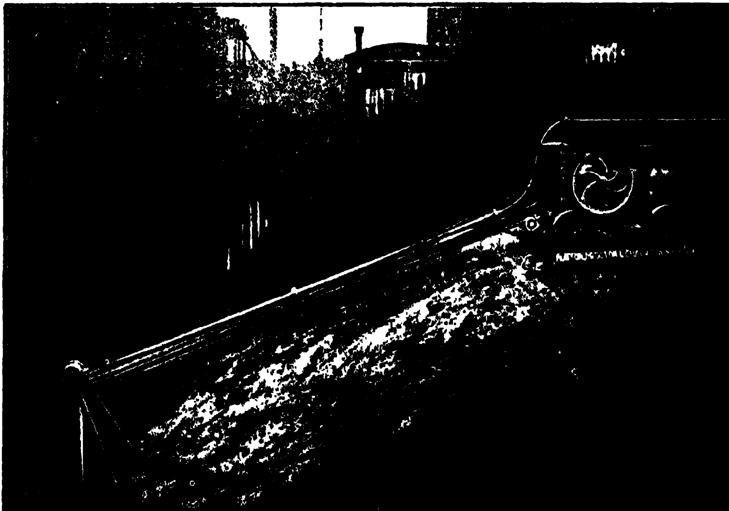
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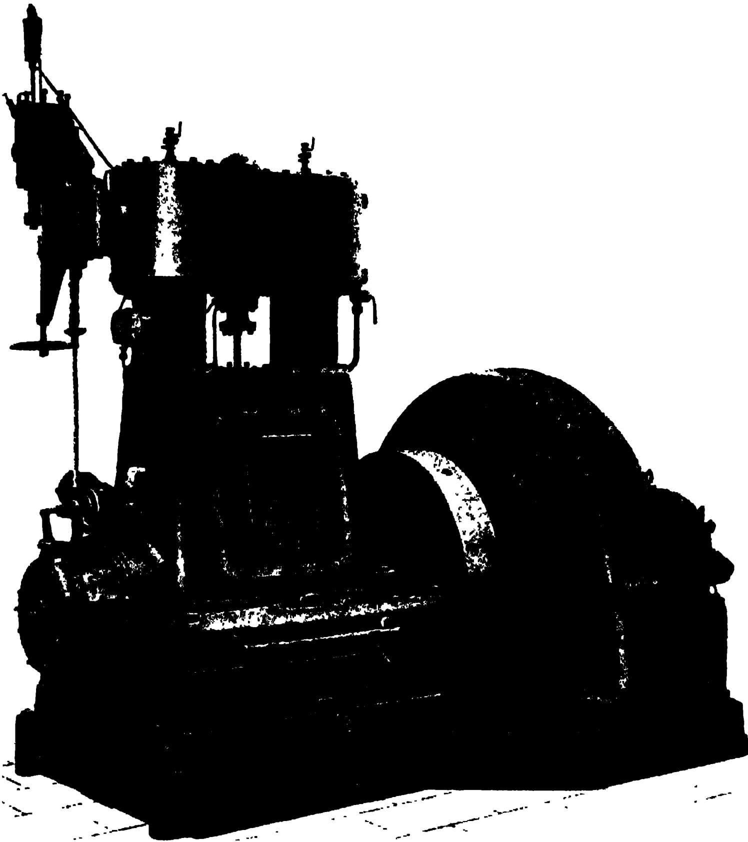
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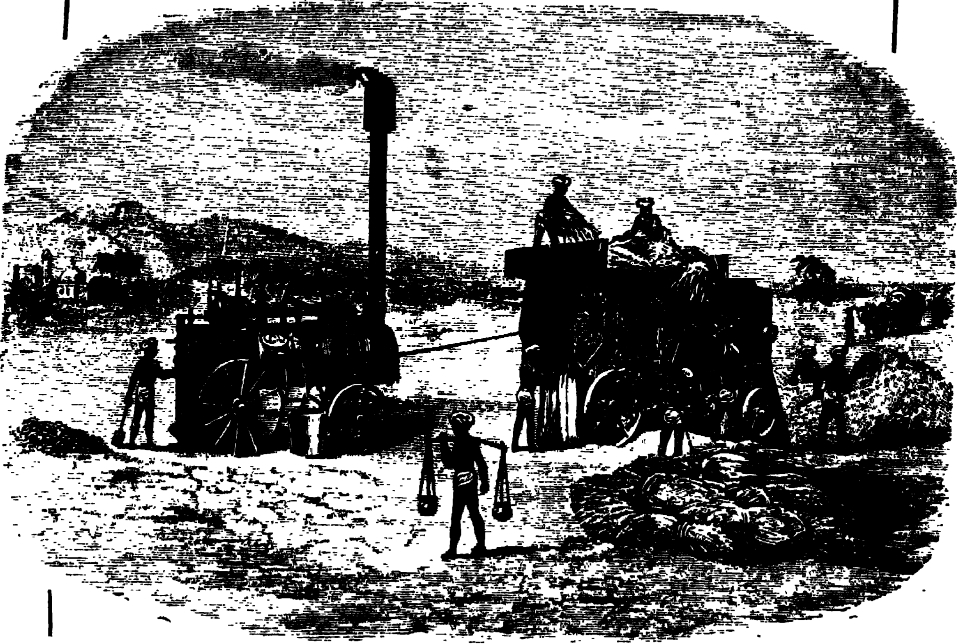


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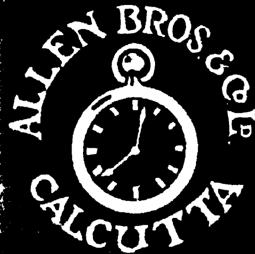
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THE PHOSPHATE DEPLETION OF SOILS OF BIHAR AND ITS CONTINGENT RISKS OF MALNUTRITION AND ENDEMIC DISEASE: A WARNING.*

BY

WILLIAM A. DAVIS, B.Sc.,

Indigo Research Chemist to the Government of India.

THERE is no doubt that most of the lands in Bihar (with a few exceptions, such as the fresh alluvium brought down each year by the Bagmuttee which contains considerably more phosphate than that of other rivers) are in a dangerously exhausted condition as regards available phosphate. The system of continuous cropping with no other manure than indigo *seet* (which gives back to the soil less phosphate than corresponds with a single indigo crop) applied once in the rotation, has gradually and almost completely stripped the soil of this essential constituent. Where comparative analyses are available of the same soils at intervals during the past twenty years the rapid falling off of the small quantity of phosphate still remaining is clearly visible. At the present time, wherever manurial experiments have been made in Bihar (the Pusa experimental plots, Dalsing-sarai, Dooriah), it has been found that superphosphate gives maximum returns, the crop being frequently more than doubled. The addition of other chemical manures such as sulphate of potash or ammonia without superphosphate frequently gives no better results than on the unmanured plots; whilst when added to

* Received for publication on 30th October, 1916.

superphosphate they give no further increase beyond that caused by phosphate alone.

The object of the present paper is to emphasize that this impoverishment of the soil has its effect not merely on the actual yield of the crops but on their *quality*, and that a further falling off of nutritive value of the crops carries with it grave risks of malnutrition and endemic disease.

It is well known that the outbreak of beri-beri is generally regarded as associated with the use as main diet of polished rice containing a deficiency of essential nutritive substances. In 1897, Eykmann found that the addition of rice-bran to polished rice prevented the outbreak of this disease and recently yeast extracts have been found to act as a cure in similar cases. Whatever be the nature of the essential constituent which is lacking in polished rice, the percentage of phosphoric acid is generally accepted as an index of the beri-beri producing power of a sample of rice. Rice having 0·47 per cent of phosphoric acid has been found to be a healthy food for fowls whilst rice with only 0·28 per cent brought about polyneuritis in a few weeks.

A valuable study of the composition of the rices of Bihar has recently been made by J. N. Sen, Supernumerary Agricultural Chemist (*Pusa Bulletin* no. 62) which shows that whilst many of the polished rices contain from 0·4 to 0·5 per cent of phosphoric acid, 7 out of 18 samples were dangerously near the limit 0·28 per cent, three samples containing less than 0·29 per cent. One sample from Sabour contained 0·27 per cent.

Now the deficiency of P_2O_5 in the rice grain is undoubtedly to be attributed to a deficiency of phosphate in the soil on which it is grown. Four out of the five samples of rice grown at Sabour showed decidedly low values for P_2O_5 *viz.*, 0·27 to 0·33 per cent. As appears from a second paper by Mr. J. N. Sen (*Pusa Bulletin* no. 65) the Sabour soil contained only 0·11 per cent of total phosphoric acid, a value which is however probably higher than would be given by many other soils in Bihar to-day. The phosphoric acid in the rice grown at Sabour was, too, always far lower than

Hawaiian rice which was grown on a soil containing 0·48 per cent of $P_2 O_5$.

It may be argued that any deficiency of nutritive constituents in rice can be made up by supplementing the diet, as is usual, with other foods. But many of these foods, for example pulses, grown on the impoverished soils of Bihar are also probably deficient in phosphates and fall short to a corresponding extent of their full nutritive value.

The nutrition of the cattle of this district will be affected also by a deficiency of phosphate in the food. This factor will limit their growth and also the milk they are capable of yielding. It is well known that the native cattle of Bihar are small and give far less milk than the cattle in many other districts, where the soils are more favourable so that good nutrition is possible.

The position of Bihar to-day is strikingly similar to that in many districts of England early last century prior to the introduction of superphosphates by John Bennet Lawes. Large towns were then growing up and the continual removal of crops and dairy produce, especially the latter, impoverished soil and pasture. The introduction of superphosphate had a marvellous effect in increasing the fertility of the country and the yield of the dairy produce. The pasture land revived and, owing to the far larger crops, obtainable from arable lands, especially root crops, it became possible to keep more cattle. These indirectly greatly helped fertility by supplying larger stocks of farmyard manure. It would perhaps be unsafe to prophesy that the increased depletion of the phosphates in Bihar will necessarily be followed by a spread of beri-beri, but there is a distinct danger that this may be so. There is, however, no doubt that the rices of Bihar and possibly other crops are deficient in a vitally essential constituent. Both quality and quantity could be improved by the addition of phosphate to the soil.

The most urgent need, I consider, of the soils of Bihar is systematic manuring with phosphate. Wherever this has been applied on the large scale, for example at Dalsing-sarai where for several years Rs. 10,000 per annum has been expended on phosphates,

the increased returns have far more than justified the expenditure. When as an " economy " the phosphate manuring at Dalsing-sarai was cut down, the crops fell off in a surprising manner and phosphate manuring was again resorted to with good results.

It is desirable from the standpoint of improving the nutritive value of rice that systematic experiments be initiated to ascertain the best form of manure in which phosphate can be supplied to this crop. It is probable that under the conditions in which rice is grown, superphosphate would be too soluble a form to apply economically and that ground rock-phosphate might be used with advantage. The bacterial conditions under which a rice crop develops are abnormal and it is highly probable that the crop could directly assimilate sufficient phosphate from the rock-phosphate if the latter were mixed with the soil so as to increase the total phosphate, which the analyses made hitherto show to be generally very deficient.

THE IRRIGATION OF ALLUVIAL SOILS.*

BY

ALBERT HOWARD, C.I.E., M.A.,
Imperial Economic Botanist,

AND

GABRIELLE L. C. HOWARD, M.A.,
Second Imperial Economic Botanist.

I. Introduction.

THE traditional method of irrigation on the alluvial soils of India is surface-flooding. Only on the highly-manured, market-garden soils near the cities is this practice departed from in favour of some crude system of furrow-irrigation. As long as surface-flooding is confined to watering from wells or from inundation canals, no particular harm is done to the land. In the case of wells, the water has to be lifted by cattle power to a considerable distance before it can be employed. This naturally leads to economy in the amount used and also in the methods of distribution to the land. After watering, the surface crust (*papri*) is often broken up by hand and all weeds are removed. Well-irrigation, applied to crops like wheat, of necessity approximates to garden cultivation. In the case of watering from inundation canals, the land is ploughed up as soon as possible after irrigation and no further watering is necessary.

With the development of canals, however, and the introduction of perennial irrigation on the alluvial soils of North-West India, it was not long before unmistakable signs of deterioration made their appearance. These apply both to matters of agricultural

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practice and also to the inherent producing power of the soil. With an abundant supply of water, the cultivator is tempted to apply too much and to irrigate too frequently. Weeding is neglected and little or no attempt is made to break surface crusts for promoting soil-aeration and for making the water go further. The result is the speedy destruction of the aeration of the sub-soil, the crops are forced to develop surface roots and ripening can only be brought about by the use of relatively enormous quantities of water. This defective practice has brought in its train a whole set of misfortunes. The spreading of excessive amounts of water over the land has sometimes raised the sub-soil water-level so near the surface as to produce swamp-like conditions. The producing power of the land of such areas has fallen off, the resistance of the people to disease has declined, and, in consequence, the inroads of malaria have become serious. Injurious alkali salts have sometimes accumulated in these semi-water-logged tracts to such an extent that cultivation has had to be given up. Diseases of crops like wheat-rust have tended to lower the yield of irrigated wheat particularly in years when the spring rains are abundant.[1] The net result of all this is that the standard of agriculture in the areas served by canals has fallen markedly below that of the well-irrigated tracts. Perennial irrigation in the plains of India is by no means an unmixed blessing and there is no doubt that the time has come for the consideration of modifications of the method designed to remove at least its most obvious disadvantages.

In the monsoon-fed areas of the plains, there is another aspect of irrigation which is of considerable importance. This is surface drainage. Where water has to be carried to the fields either from wells or from canals, the whole country-side becomes intersected with channels and other impediments to free surface drainage. The result is that the surplus rainfall often stands on the ground for long periods giving rise to local water-logging and to a considerable

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[1] The connection between the incidence of rust and soil-aeration is undoubted. One of the surest methods of producing a rust epidemic is to sow wheat on heavy land which has been water-logged in the monsoon and which is afterwards on the moist side due to rain or to over-irrigation.

amount of denitrification. The effects of this water-logging are particularly evident on the succeeding wheat crop in the shape of weak growth which produces very poor yields. It is easy, by mere inspection of the wheat fields, to pick out the places where water stood on the surface during the rains. These areas of low yield are often as much as half the total surface so that the damage done from this cause must in the aggregate be very great.[1]

The existence of numerous water-channels and bunds is harmful in another way. The obstruction to the natural surface drainage is one of the great obstacles to the spread of green-manuring. The first condition necessary for the success of this method of soil-enrichment is a copious supply of air for the complete decay of the green manure before sowing time comes round for the succeeding *rabi* crop. Unless the surface drainage is ample and water-logging is prevented, adequate soil-aeration is obviously impossible and the ploughing in of a green crop does more harm than good by introducing another competitor for the limited amount of oxygen in the soil. The great need of alluvial soils, which are constantly cropped, is however organic matter, and provided this material can be added to the land without interfering with the oxygen supply, wheat and other crops respond at once and give greatly increased yields. If this enrichment can be brought about by green-manuring, crop-production on the Gangetic alluvium will enter on a new phase.

These considerations enable us to state the conditions underlying any successful modification of the existing methods of irrigation on the plains of India. What is wanted is a system which fulfils the following conditions :—

(1) The amount of water used must be as small as possible.

(2) The method of distribution must be simple and inexpensive, and must be designed to admit of the use of labour-saving devices such as harrows and reapers.

(3) The system must admit of *surface drainage for each field* during the rains, and it must be such as to prevent the production of alkali salts.

[1] See *Bulletin No. 53, Agricultural Research Institute, Pusa*, 1915, p. 9.

(4) The method must be such as to assist the process of green-manuring in those areas where this is possible.

As a result both of first-hand experience gained in irrigation work at Quetta and also of numerous observations in the canal-irrigated areas of India, a method of applying water to land has been devised which appears to be a considerable improvement on present practices. A large amount of water can also be saved, both on the fields themselves and also in the channels. The question of the increased duty of water in India at the present time is one of considerable importance. Most of the supplies have already been utilized, but large areas of desert still remain unconquered. Any great extension in irrigation can only be achieved by spreading the present supplies over larger areas. In the monsoon-fed tracts, where irrigation supplements the rainfall and is regarded as a protection against famine, the soil can most easily be made to grow larger crops by providing for surface drainage and thus opening the door to green-manuring. It is suggested that the method of irrigation described in this paper will, if intelligently applied, achieve all these objects.

II. THE GROWTH OF WHEAT AND GRAM ON A SINGLE IRRIGATION.

The provision of perennial irrigation in India has not been without its effect on the character of the cultivator. If water is provided in abundance and payment is arranged for according to the area watered, instead of by the volume of water used, it is easy to understand that the ryot will not exert himself to discover methods of using less water. The consequence is that in some parts of India, for example in Baluchistan and in the Punjab, a system of perennial irrigation has grown up which is not always necessary. Crops like wheat, for example, are watered periodically largely because the water is there. If the soils were not alluvial in character and if their physical composition were such that surface-flooding had no effect on their porosity, these unnecessary waterings would do no particular harm beyond wasting the water itself. Silt-like alluvial soils, however, are as a rule by no means porous

and the chief difficulty in their cultivation is to preserve the tilth so that the roots of the crops and also the soil organisms can obtain a sufficient quantity of air.[1] Surface-flooding is particularly destructive to the tilth of these soils and, wherever possible, any watering necessary should be done before the crop is sown and not afterwards. Every drop of excess water applied after sowing to soils like those in the Quetta valley and most of the types found in the plains does actual harm by cutting off the air supply.

The full value of a single irrigation for wheat on alluvial soils is hardly realized at present. In a previous paper, the results obtained in this direction at the Fruit Experiment Station at Quetta are fully described and their applicability to Indian conditions indicated.[2] On the light lands at this Station, a single irrigation applied before sowing, supplemented by the winter rains, produced an average of 17¾ maunds of wheat to the acre—four and a quarter maunds above the average yielded by similar unmanured land in the locality with six or seven irrigations.

During the past wheat season, this method has been tried on a *zamindar's* land near Quetta. The field was irrigated once on September 30th before sowing and no further water was applied. The rainfall during the year is given in Table I. The yield of grain was higher than was expected and was found to be 22 maunds 33 seers per acre.

TABLE I.

Rainfall in inches at Quetta, 1915-16.

	1915-16
July	*nil*
August	*nil*
September	*nil*
October	*nil*
November	*nil*
December	*nil*
January	2·61
February	1·53
March	0·28
April	1·99
May	0·75
June	*nil*
TOTAL	7·16

[1] See *Bulletin No.* 52, *Agricultural Research Institute, Pusa*, 1915.

[2] The saving of irrigation water in wheat growing, *Bulletin No.* 4, *Fruit Experiment Station, Quetta*, 1915.

As the crop was reaped on June 9th, the total rainfall which fell after sowing amounted to 7·16 inches. Only a portion of this rainfall, however, affected the yield as is proved by the fact that the lateness of the winter rains led to the almost complete failure of the dry-crop wheat in the Quetta valley.

A yield of 22 maunds 33 seers to the acre with a single preliminary watering in an unfavourable season like 1915-16 shows the enormous possibilities of this method of water-saving. Success depends on making the most of the single irrigation and on the use of the harrow afterwards in breaking rain-crusts. To make the most of the single watering, the cultivator needs a new implement in addition to the country plough and the levelling beam (*sohaga*). He must preserve the moisture, produce a good tilth, and at the same time avoid the formation of clods. All this can easily be accomplished by the use of the spring-tine cultivator or by the harrow. As soon as the surface of the land has dried sufficiently to bear the work cattle, it must be gone over with this cultivator or harrow, followed at once by the beam. In this way, the surface of a comparatively large area of land can rapidly be broken up by the harrow. If this operation is at once followed by the beam, a thin layer of fine soil is produced which acts as a surface mulch. The result is that the rate of drying slows down and a perfect tilth is produced by natural means without any cultivation. Three or four days later, the land is ready for sowing, an operation best carried out behind the plough or by the country drill. If an attempt is made to prepare irrigated land for sowing by means of the country plough only, the result is an enormous waste of water and a poor tilth. Before the plough can get over the land, a large portion becomes too dry and clods form. The result is that most of the water is lost by evaporation and an exceedingly poor tilth is obtained. There is too little moisture for the young wheat, the root-development of which suffers from the poor texture of the soil.

Besides wheat, there are other crops which can be ripened on a single irrigation applied before sowing. One of these is gram (*Cicer arietinum*, L.) which, as is well known, can only be watered

with advantage on porous soils or on soils naturally underdrained.[1] On soils like those of the Chenab Colony, gram does not thrive under surface-flooding as the land is too stiff for this process in the case of leguminous crops. If, however, on such soils, a single irrigation were given to the land before sowing, it would be easy to dispense with subsequent waterings. There is said to be one drawback, however, to the rapid adoption of this practice on the Chenab Colony. If a cultivator were to grow gram on a single watering, we understand that he would be charged full rates and that there appears to be no provision in the existing rules for such a simple water-saving device as a special rate for one irrigation. It would not appear to be a difficult matter to grant a specially low rate for a single watering in the case of gram and so encourage the growth of this crop in rotation with wheat. Besides increasing the duty of water, the gram-wheat rotation would do much to maintain the fertility and increase the aeration of the soils of irrigated areas such as those of the Canal Colonies of the Punjab.

III. An Improved Method of Irrigation.

Any improved method of irrigation in India must deal effectively with the two main defects of the existing methods—the inferior preparation of the surface to be watered, and the inefficiency of the field channels.

It is impossible to pay too much attention to the surface to be irrigated. The land must be perfectly graded and free from depressions and high areas. The irrigation water must flow slowly and evenly over the field, all parts of which must absorb practically the same quantity of moisture. After irrigation, there should be no water standing on the surface for long periods and the crop should be level to the eye and of a uniformly green healthy colour. Imperfect grading not only means waste of valuable water but in the low-lying, over irrigated areas, denitrification occurs with the result that a great loss of crop takes place.

The field channels must be as short as possible so that the losses in percolation are reduced; they must command the maximum

[1] *Memoirs of the Dept. of Agr. in India* (*Botanical Series*), vol. VII, no. 6, 1915, p. 217.

possible area ; they must be laid out so that surface-drainage is not interfered with and they must have strong berms to prevent bursting. The field channels should be regarded in the same way as roads. When a road is improved it carries more traffic and also reduces the force necessary to move each unit of weight. Field channels are the water roads of the cultivated area. A very little expenditure of labour would improve these communications beyond recognition and would also assist in the control of the irrigation water.

1. Preparation of the land for irrigation.

Grading. In almost every case, some grading is necessary before water can be applied to the land to advantage. A variety of implements have been devised for this purpose which are readily adapted for bullock power.

In Baluchistan, all grading is done by the *ken* which is nothing more than a slightly curved board, provided with a handle above and rings at the sides for attachment to the yoke. The lower edge which acts as a scraper is strengthened with sheet iron. The size is roughly 3′ × 2′ 4″ and one pair of cattle is commonly employed. The local labour is exceedingly expert with this primitive grader and they rapidly and accurately prepare for irrigation the narrow terraces on the slopes of the valley. Earth is collected from the high places and deposited in the low areas by simply altering the slope of the *ken*. In an intermediate position, the instrument carries its load of earth without disturbing the level of the ground passed over.

In the Punjab, a very similar instrument, drawn by two pairs of cattle, known as the *karah*, is in use. It is practically the same in principle as the Baluchistan *ken*, but is more adapted for grading the large fields in the Canal Colonies. At Quetta, both the *ken* (for one pair of cattle) and the *karah* (for two pairs) have been found useful in preparing the plots for irrigation. The taking of levels is not necessary as the workmen can prepare by eye the desired slope with remarkable accuracy. All that is necessary is to test the preliminary work by watching the flow of the water in a few trial irrigation channels thrown up on the new surface. The

indications thus given enable the workmen to rectify any slight defects which may exist.

One precaution is very desirable in grading land in India. As is well known, the surface soil is always richer than the sub-soil. Any concentration of surface soil in one place and any corresponding exposure of the lower soil layers in another leads to uneven growth which does not disappear for some years. It is best therefore before beginning the grading to scrape off the upper three or four inches of the soil and to collect this on one edge of the field. The sub-soil is then graded to the extent desired after which the upper soil is rapidly and evenly spread over the whole with the *ken*. In this manner even crops result.

The plots at the Fruit Experiment Station, Quetta, are oblong in shape and have been prepared with a slope of approximately 1·5 inches in 100 feet in two directions—the irrigation channel entering each plot at the highest corner. As the original slope of the land was considerable, the old surface has been transformed into a series of terraces, the plots of which are about an acre in area. Two bricked channels conduct the irrigation water down the somewhat steep slopes and lead it to pairs of plots on either side.

Laying out the land for irrigation. It is a general rule in India that the larger the water supply the less is the care bestowed on laying out the compartments (*kiaris*) for irrigation. When the water has to be raised from wells and the supply is small, the size of the *kiari* is adjusted to the flow and care is taken to water the compartments in pairs from a central temporary channel. In canal irrigation, however, the *kiari* is large, often square in shape and water is often passed over a watered compartment into the next thus leading to uneven percolation and to a great waste of water. If the land is properly graded so that water will flow over the surface evenly without carrying soil with it, there are obvious advantages in the long oblong compartment watered from one end. In this method, the temporary bunds are parallel to the direction of flow and thus have to withstand very little water-pressure. In consequence, breaches are exceedingly rare and the water is kept under strict control. The length and width of the oblong compartment

depend largely on the amount of water available. At Quetta, where the supply is small, the *kiaris* are not often more than twelve feet wide while the length may be as much as four hundred feet. In canal irrigation, however, the breadth could be much greater and the length could also be increased. In irrigating under such conditions, the water spreads itself over the *kiaris* quite evenly and flows onwards at the rate of about three hundred feet in half an hour. Before the flow reaches the far end, the water is cut off and led into

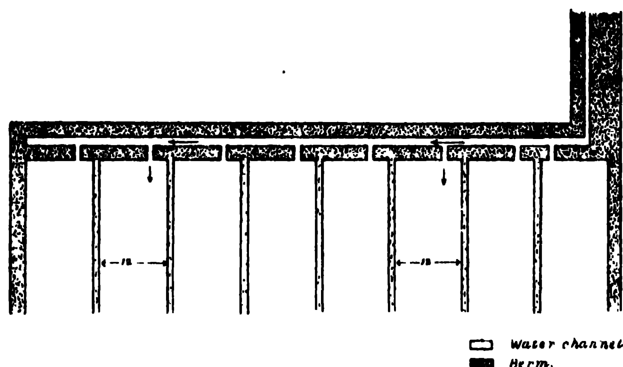


Fig. 1. Irrigation with long narrow compartments.

the next compartment. With a little practice it is possible to water exceedingly evenly and to raise absolutely uniform crops. One of the best methods of determining whether the percolation is even is to watch the drying of the surface. It should begin to dry near the

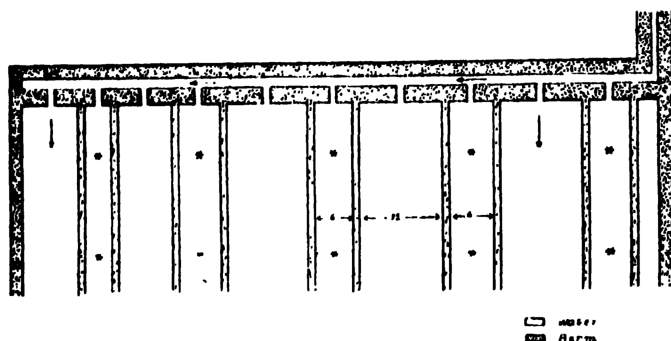


Fig. 2. Irrigation of fruit trees.

inlet, but the difference in time between both ends of the compartment should not be very great. The fact that the upper end begins to

dry first shows that the slope is a little too great for even percolation in the absence of a crop. The resistance of a crop like lucerne or *shaftal,* however, corrects this and leads to even watering.

The arrangement of compartments in one of the Quetta plots is shown in Fig. 1. Here the wide *kiaris* are twelve feet broad and four hundred feet long—an arrangement which is very suitable for *shaftal* or lucerne with a small water supply.

Where fruit trees are concerned and where fodder crops are grown between the rows while the trees are young, only a slight modification of this arrangement is required. This is illustrated in Fig. 2. The method enables the strip of land in which the trees are growing to remain unwatered and to act as an aeration area for the whole surface. This is an important matter in soils like those of the Quetta valley which rapidly pack under continued surface-flooding.

Besides their advantages in the economy of water and in the saving of labour during irrigation, the long oblong *kiaris* make crust-breaking after irrigation by harrows a very simple matter.



Fig. 3. Irrigation and drainage.
A, irrigation channel. B, drain.

The *papri* can be broken without levelling the temporary ridges. The harrows can either be lifted from one bed to the other over the bund or else the bunds at one end of the plot can be repaired after the operation is completed. The use of reapers is also rendered easy. Two strips can either be treated as one field by the simple process of levelling the bunds at each end after the last irrigation or each strip can be cut separately.

Surface drainage. In the monsoon-fed tracts of India any method of irrigation to be effective must allow for surface drainage and for the rapid removal of the run-off. The long oblong *kiari* graded for flow-irrigation provides an ideal surface for getting rid of surplus rain water. All that is necessary is to provide a surface drain with sloping sides at the end of the field, and during the monsoon to level off the low temporary bunds (for retaining

irrigation-water) at the end of each *kiari* next to the drain. One field distributary and one of these drains will usually serve two sets of fields, the arrangement being that indicated in Fig. 3.

The drainage channels can be connected together into a suitable system and the run-off can be led either to low-lying rice areas or to rivers and *jhils*. Not only does such a system prevent denitrification during the monsoon, but it also materially assists in the successful introduction of green-manuring—a process which depends for its success on ample aeration of the soil for the rapid decay of the green crop.

2. Field channels

Both in the case of wells and canals, the feature of irrigation in India is the poor quality of the field channels. There is also a want of proper control over the water in the channels. In well-irrigation, the sides of the channels are always weak and breaches are frequent, leading to loss of water and to loss of time in temporary repairs. In canal areas, the amount of water lost by the bursting of the smaller channels is enormous and it is almost impossible to see canal irrigation in progress without the production of large roadside puddles which must have used up sufficient water to irrigate at least half an acre of land. The control of the irrigation water in the channels themselves is likewise defective. The usual method is to stop the flow by a temporary earth dam, dug out of the field. Water is led into a new area by cutting an opening in the side of the channel. The result is frequent breaches of the temporary dams in the channel, the loss of water and the formation of a large number of water-logged depressions caused by the removal of the earth. In the canal tracts, these serve as admirable centres for the breeding of mosquitoes.

Improved water channels The first condition of control of the irrigation water in the field channel is the provision of a broad earthen berm which is allowed to grass over. The berms of the field channels should be at least 24 inches wide, and the upper surface should be flat so as to serve as a path. The size of the channel should be such that when it carries the full flow it should not be

more than three-quarters full. The openings into the *kiaris* should be as permanent as the berms and care should be taken to grass them over on all three sides to prevent cutting by the irrigation stream. The arrangement of the permanent field channels at Quetta is shown in Fig. 1. The field channels should be regarded as permanent structures and the earth necessary to make the broad berms should be deposited by the *ken* at the time of laying out. *Dub* grass readily grows over these berms, thus making them permanent and also providing a useful amount of fodder.

The control of the water. The best method of controlling the water in the channels is by means of the canvas dam in use in the United States. This is merely a piece of canvas or stout cotton cloth like drill fixed to a strip of wood or bamboo. The wood is laid across the berms of the channel and the canvas, when weighted by a brick, checks the water completely. Smaller canvas dams can, if necessary, be used to block the permanent openings towards the *kiaris*. One of the canvas dams in use at Quetta is shown to scale in Fig. 4.

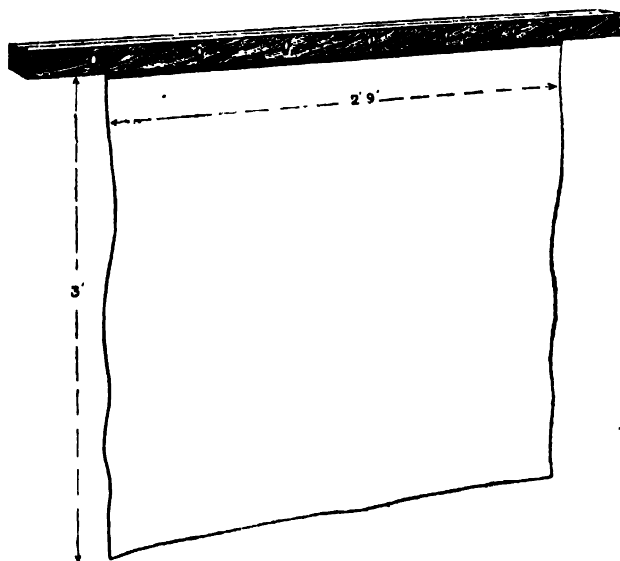


Fig. 4. A canvas dam.

Since the field channels at the Fruit Experiment Station at Quetta have been made permanent in the manner described above

and since the canvas dam has been in use, the labour required in irrigating has been greatly reduced, the work is more efficiently performed and a large amount of water has been saved. It will naturally take time for these methods to spread in India, bu there is no reason why every Government farm and every demonstration area could not immediately adopt them as an object-lesson for the people.

IV. Application of the Method to Indian Conditions.

In addition to flow irrigation, the method described above is applicable to the system of watering by means of furrows. In some respects, furrow-irrigation is a great advance on surface-flooding as by the former method water can be applied without destroying the tilth while there is also less loss by evaporation. The great advantages of furrow-irrigation are recognized in the United States, and in the case of fruit orchards in particular it has largely replaced surface-watering. In applying it to India, however, it must be borne in mind that the provision of water is only one of the uses of irrigation. The soil-temperature factor is an important one and it must be remembered that nearly all the *rabi* crops in Northern India only thrive really well if the ground is cool at sowing time and if this condition is maintained till ripening begins. Furrow-irrigation certainly does not cool the land to the same extent as surface-flooding and this aspect of the case must always be kept in mind when applying American irrigation methods to Indian conditions.

Speaking generally, there is no question that the time is rapidly approaching when Indian agriculture will be bound to adopt more efficient methods. The cost of labour is rising all over the country and already, in certain tracts like Sind and the Punjab, the supply often falls below the demand. The claims of the urban areas for workers are likely to increase with the spread of factories and with the improvement of communications. Once the supply of labour diminishes sufficiently, agricultural work is bound to become more organized in order that the men available may increase their output. Agriculture will then become more orderly, the small inefficient

holding will disappear, labour-saving devices will make their appearance more and more and there will be less waste of effort. The rise in the standard of living will assist in bringing about reforms in all directions including the details of irrigation practice. The existing water supplies will have to go further and irrigation will have to be done with less labour than at present. When the time comes, it is desirable that the Indian Agricultural Department should have ready to hand methods of irrigation suited to the new conditions. The object of this paper is to draw attention to this question and to suggest a possible solution. Up to the present, irrigation in India has been looked upon largely as an engineering problem. This is correct in so far as the making of canals is concerned, but the real value of irrigation to India depends largely on a proper appreciation of the needs of the crops irrigated. In other words, the maximum results of irrigation will only be realized if the matter is regarded as one of applied physiology. Crops need other things besides water.

THE AFTER-RIPENING OF CANE.

CHEMICAL CHANGES WHICH TAKE PLACE AFTER CUTTING.*

BY

J. H. BARNES, B.Sc., F.I.C., F.C.S.,

Agricultural Chemist, Punjab Agricultural College, Lyallpur.

In the modern factory system which requires a constant supply of large quantities of cane, any deterioration of the sugar contents of the crop in its passage from the field to the mill may constitute a serious loss. Such losses have not been overlooked by previous workers, but it was not at all certain that they are uniform or that the results obtained in a hot moist climate would necessarily apply to a colder climate like that of Northern India. In the Gurdaspur District, it is a fairly common practice with the peasant farmer there to allow his stripped cane to remain in heaps for a day or so before crushing, the reason given being that the *gur* obtained from such cane is drier and lighter in colour than it the cane is crushed immediately. This seems to indicate that storage helps to ripen off the cane. The ripening of cane like the ripening of any other crop is usually evidenced by the storage in a complete and finished manner of the reserve food supply needed for the nourishment of the young plant in the following season. In the case of cane, which is usually reproduced by setts, the reserve food is in the form of the biose sugar *sucrose.* When the cane is in an unripe condition, it contains a comparatively small amount of sucrose and a correspondingly large amount of invert sugars of the type of *d* and *l* *glucose.* As the crop ripens, the amount of invert sugar gradually diminishes and the amount of sucrose increases

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but not in any equivalent proportion. Whatever may be the function of the invert sugars—whether they form a link in the synthesis of the sucrose or whether they are only food for the growing plant, or whether they serve both purposes, will not be discussed here. We are here concerned only with the fate of sucrose. This goes on increasing in amount as the crop ripens until when fully ripe nearly the whole of the sugar to be detected in the juice is sucrose. The best types of cane contain, when ripe, little or no invert sugars and this is an important point in the manufacture of refined sugar when the product is to be a crystallizable sugar and any invert sugars collected constitute a by-product in the making of sucrose.

When the cane is nearly ripe, it requires less water than when young or half grown and during the last stages of growth the less water it gets the better. In this respect the ripening of cane is in line with the ripening of all crops, namely, that a curtailment of the water supply of the mature crop induces ripening. To put it in another way, ripening is a water starvation phenomenon.

When the setts are placed in a warm and damp soil, the buds at the nodes begin to grow. During this stage, we find that the amount of sucrose begins to fall and the amount of invert sugars to increase. This is brought about by the hydrolysis of the sucrose by several enzymes of which cytase and invertase are the chief. The function of the invert sugars is the nourishment of the young shoot until it can fend for itself.

When cane is cut for milling, there is a danger of sugar degradation taking place if the climate is warm and damp and if too long a time is allowed to elapse between the cutting and milling of the cane. A similar and even more rapid decay takes place in the juice if this is allowed to remain standing for any length of time after extraction. It is then this decay in sugar which the factory owner fears and he guards against it by working up his cane as soon after cutting as possible.

The question has naturally arisen how long may the cut cane be kept without causing a loss or if storage of the cut cane is

inevitable what are the extents of the losses which will be incurred.

Weinberg[1] gives the following losses which take place in the available sugar, *i.e.*, *sucrose* on storing the cut cane.

TABLE I.

Days after cutting	0	1	2	3	4
Available sugar in original sample ...	100·0	97·3	92·0	78·6	67·9
Total loss of available sugar ..	0·0	2·7	8·0	21·4	32·1
Daily loss of available sugar ...	0·0	2·7	5·3	13·4	10·7

According to Deerr[2] it has been shown in Java that cut cane deteriorates much less rapidly when moist than when dry and he attributes this deterioration to the death of the cane cells. When for reasons of breakdown or cause of delay in milling, it is necessary to keep a quantity of cut cane it is customary in Java to cover the cane with trash and moisten this with water.

This appears very reasonable up to a certain point, that is so long as the cell protoplasm is alive and when the ordinary chemical processes of the cell can continue. It is only when this is dead that the chemical reactions of hydrolysis and oxidation by the enzymes contained in the sap will get beyond control. It seems unlikely that the large losses indicated in Weinberg's table should have resulted from the action of bacteria—moulds and fungi, though these may have contributed in part—it seems more reasonable to suppose that the chemical changes of deterioration have been set up in the cell itself. This aspect of the problem has received special attention from the author and the results of this enquiry will be the subject of a separate paper.

The first change which certainly takes place after cutting the cane is a loss in weight due to a loss of water. If the leaves are left attached to the stem after this has been cut, the loss of water will be much more rapid than if the leaves and tops are removed since these accelerate the loss of water by transpiration.

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[1] *I. S. J.* 59.

[2] *Cane Sugar*, page 169.

According to Deerr, the average daily loss in weight from heaps of cane of about 50 lb. was as follows :—

TABLE II.

Percentage loss in weight of cut and heaped cane.

In 24 hrs.	48 hrs	72 hrs.	96 hrs.	120 hrs.
2·73	5·00	6·37	8·81	9·11
2·53	4·49	5·45	8·01	9·01
3·03	3·50	5·19	7·88	8·80
1·59	3·62	4·63	6·26	7·64
1·87	4·48	5·49	6·64	8·02
2·26	4·05	6·11	7·90	8·50
1·41	3·05	5·20	6·09	8·52
Mean ... 2·19	4·03	5·49	7·37	8·57

These figures are interesting but they are of *local value* only so far as the actual amount of the loss is concerned because the amount of the loss will vary considerably with the variety of cane, with the temperature and with the humidity of the air. They are interesting because they prove what, we should expect, actually takes place. The loss of water which occurs when cane is stored affects the mill-owner because he has now to deal with a cane which contains less juice and though this may be in a more concentrated form still the efficiency of his mill will be reduced by a more than proportional amount. For when a cane containing (V) volumes of water, with (P) per cent of *sucrose* in solution, loses (v) volumes of water by evaporation so that (V) becomes ($V-v$), then (P) becomes (p) per cent of *sucrose*. When (p) is greater than (P) by the proportion $\frac{V}{V-v}$

$$p=\frac{PV}{V-v}$$

If (x) volumes of the water containing (y) grams of sugar are left in the bagasse when the above cane is milled, then if the above concentration has taken place, (x) still remains constant and (y) increases in the ratio $\frac{V}{V-v}$.

The loss of sugar in the bagasse will now be $y\,\frac{V}{V-v}$.
The efficiency of the mill is in the first instance $P-y$.

In the second case after concentration of juice has taken place, the efficiency has fallen to $P - \frac{yV}{V-v}$.

If, in addition to this, a degradation of sugar also takes place, the factory losses will be still further increased.

But we have seen that under certain conditions, *viz.*, among the *zamindars* of the Gurdaspur District, a certain amount of concentration of the sugar juice is regarded as actually beneficial in giving a purer product. If this is the case and if we regard the ripening of the cane as a water starvation phenomenon then the loss of a limited amount of water will result in ripening off the cane and if this is in an unripe condition when cut, the benefits obtained may be more than the milling losses. This seems to be the only feasible explanation of the country practice I have described.

In order to test this theory of the ripening off of cut cane, a number of experiments were made on the effect of storing cane on the chemical composition of the juice. Since loss of water takes place, it is necessary to know what this loss is in order to compare the composition of the juice before and after storing. Instead of directly measuring the moisture lost which is a lengthy and tedious laboratory process I determined the increase which resulted from the concentration in the total solids contained in solution. This is a simple and easy determination as it merely involves the use of the hydrostatic balance and a Brix's table. We can then refer all changes which take place by reference to *the percentage of sugar in the total solids.*

The following two tables will illustrate this point. Table III gives the composition of the cane juice for a number of samples of *Katha* or *Chin* cane. In all the cases the cane was cut and stripped of leaves in the usual manner—a part was crushed and the juice examined at once and the other part was kept in the laboratory for 24 or 48 hours after which it was again milled and the juice examined. In some cases the cane stems were coated with paraffin wax to prevent loss of moisture. In some cases the cane tops were left attached, in others they were removed.

In Table IV we have the same analyses recorded in Table III but in this case the *sucrose* is calculated not in terms of per cent in the

juice *but as per cent on the total solids.* This gives us at once a real measurement of the increase or decrease in sucrose which has taken place as the result of storing the cane and is analytically independent of the actual loss in moisture. As a result of twenty experiments, eleven show an increase in sucrose or in other words show that ripening has continued and nine show a decrease or that sugar decay has set in. With two exceptions, the losses are not great. In these two samples, Nos. 14 and 28, it is very likely that the canes were bruised or diseased but of this there is no actual record.

TABLE III.

Special experiments on the effect of stripping the cane on the sucrose contents.

No. and date of sample		Description and locality of cane (brought from Rusa tenant chak 79 near Agricultural Station, Lyallpur) variety *Red thin Chin.*	Juice per cent	Glucose per cent	Sucrose per cent	Total solids	Glucose ratio	Purity co-efficient	Fibre on cane	Increase or decrease on the sucrose.
1	6-3 12	Analysed fresh	50·4	0·21	19 13	23·1	1 09	82·79	23·96	...
2	7-3-12	Analysed after 24 hours ..	49·6	0·37	19·58	23·1	1·89	84·78	24·14	+0·45
3	6-3-12	Analysed fresh (another stool).	52·19	0·17	17·60	22·5	0·96	78·21	22·68	..
4	7-3-12	No. 3 after 24 hours ...	50·7	0·78	18 08	23 2	4·31	77·91	22 43	+0·48
5	6-3-12	Analysed fresh (another stool).	48 7	0·12	17·72	22·2	0·68	79·82	19·13	...
6	7-3-12	Analysed No. 5 after 24 hours.	50·2	0·46	18·45	23·0	2·49	80·23	21·79	+0·73
7	6-3-12	Analysed fresh (another stool).	50·08	0·23	17·6	22·5	1·30	78·2	22·61	..
8	8-3-12	Analysed No. 7 after 48 hours.	52·07	0·34	18·86	24·2	1·80	77·93	22·10	+1·26
9	6-3-12	Analysed fresh (another stool).	52·08	0·10	19·40	23·1	0·51	83·97	23·12	...
10	8-3-12	No. 9 after 48 hours ..	50·96	0·37	19·6	24·2	1·88	80·98	22·31	+0·20
11	6-3-12	Another stool (analysed fresh).	53·4	0·20	17·62	22·7	1·13	77·62	20 92	...
12	8-3-12	No. 11 after 48 hours ...	50·4	0·38	18·9	23·9	2·01	79·07	25·30	+1·28
13	12-3-12	Another stool (analysed fresh)	52·4	0·14	17·97	21·6	0·78	83 10	24·63	. .
14	13-3-12	No. 13 after 24 hours	51·2	0·9	17·86	23·4	5·06	76·33	20·35	−0·11
15	12-3-12	Another stool (analysed fresh).	49·7	0·15	18·89	22·7	0·799	83·24	23·01	...
16	13-3-12	No. 15 after 24 hours ..	53·7	0·13	20·06	24·1	0·64	83·28	22·48	+1·17
17	12-3-12	Another stool (analysed fresh).	51·4	0·14	18·68	21·8	0·74	85·69	22·6	...
18	14-3-12	No 17 after 48 hours another stool.	46·8	0·597	21·06	25·3	2·84	83·24	22·8	+2·38
19	12-3-12	Analysed fresh ...	54·10	0·11	19·92	23·8	0·55	83·7	23·74	.
20	14-3-14	No 19 after 48 hours ...	47·0	0·58	21·89	27·3	2·64	80·34	28·22	+1·97
21	12-3-14	Another stool (analysed fresh).	50·1	0·18	19·31	23·4	0·92	82·5	25·85	...
22	13-3-14	No. 21 paraffined and analysed after 24 hours.	51·2	0·18	20·5	24·6	0·86	83·37	23·81	+1·19

TABLE III.—(*Contd.*)

No. and date of sample		Description and locality of cane (brought from Rusa tenant chak 79 near Agricultural Station, Lyallpur) variety *Red thin Chin.*	Juice per cent	Glucose per cent	Sucrose per cent	Total solids	Glucose ratio	Purity co-efficient	Fibre on cane	Increase or decrease on the sucrose
23	12-3-12	Another stool (analysed fresh).	50·6	0·096	19·67	23·9	0·48	82·3:	23·26	...
24	13-3-12	Paraffined and analysed after 24 hours.	51·0	0·102	20·92	25·1	0 48	83 35	22·42	+1·25
25	12-3-12	Another stool (analysed fresh)	55·3	0·103	18·98	23·1	0·54	82·17	21 74	..
26	14-3-12	No. 25 paraffined and analysed after 48 hours.	49·7	0·407	20·17	25·30	2·02	79·71	21·91	+1·19
27	12-3-12	Another stool (analysed fresh).	51·1	0·19	18·08	22·9	1·06	78·98	26·34	..
28	14-3-12	No. 27 paraffined and analysed after 48 hours.	50·7	1·04	17·38	25·6	6·00	67·91	24·35	−0 70
		Samples of local Dhaulu. Government Farm, Gurdaspur.								
29	10-2-12	One stool (analysed fresh)	55·66	0·46	15·53	18·7	2·96	83·04	15·82	
30	11-2-12	No. 29 analysed after 24 hours.	59 5	0·67	15·16	18·2	4·41	83·3	16·90	−0·37
31	10-2-12	Another stool (analysed fresh)	55·7	0·90	14·74	18·0	6·1	81·88	19·27	...
32	11-2-12	Same as No. 31 after 24 hours.	59·4	0·89	14 57	18·20	6·10	80·05	15·58	−0·17
33	12-2-12	Another stool (analysed fresh).	51·6	0·69	13 68	17·20	5·04	79·5	19·77	.
34	14-2-12	No. 33 after 48 hours (ends cut off).	56 8	0·33	15·15	18·5	2·17	81 0	19·33	+1·47
35	12-2-12	Another stool (analysed fresh).	56·7	0·65	13 55	17·7	4 79	79 5	15·25	...
36	14-2-12	No 35 after 48 hours (ends cut off).	58 0	0·12	14·50	18·5	0 83	78·4	16 95	+0·95
37	12-2-12	Another stool (analysed fresh).	51·6	0·69	13 68	17 2	5·04	79·5	19·77	...
38	14-2-12	No. 37 after 48 hours (ends not cut off).	54·9	0·25	14·28	17·6	1·75	81 14	19·24	+0·60
39	12-2-12	Another stool (analysed fresh)	56·7	0·65	13·55	17·7	4·79	76·5	15·25	...
40	14-2-12	Same as No. 39 after 48 hours (ends not cut off).	56·3	0·09	14 69	18·8	0·61	78·14	17·04	+1·14

TABLE IV.

Showing the effect of stripping and storing the cane on the sucrose contents.

No.	and date of sample	Description of sample (brought from Rusa tenant chak 79 near Agricultural Station, Lyallpur) *Red thin Chin*	Sucrose per cent	Total solids	Sucrose per cent on total solids	Increase or decrease in the sucrose per cent on total solids
1	6-3-12	Analysed fresh	19·13	23·1	82·79	.
2	7-3-12	after 24 hours ...	19·58	23·1	81·78	+1·99
3	6-3-12	fresh	17·60	22·5	78·21	......
4	7-3-12	after 24 hours	18·08	23·2	77·91	−0·30
5	6-3-12	fresh ...	17·72	22·2	79·82	......
6	7-3-12	after 24 hours ...	18·45	23·0	80·23	+0·41
7	6-3-12	fresh . ..	17·60	22·5	78·20	.....
8	8-3-12	after 48 hours ...	18·86	24·2	77·93	−0·27
9	6-3-12	fresh	19·40	23·1	83·97	.. ...
10	8-3-12	after 48 hours ...	19·60	24·2	80·98	−2·99
11	6-3-12	fresh ...	17·62	22·7	77·62	......
12	8-3-12	after 48 hours ..	18·90	23·9	79·07	+1·45
13	12-3-12	fresh	17·79	21·6	83·18	...
14	13-3-12	after 24 hours ...	17·86	23·4	76·33	−6·85
15	12-3-12	fresh	18·89	22·7	83·24	...
16	13-3-12	after 24 hours ..	20·06	24·1	83·28	+0·04
17	12-3-12	fresh	18·68	21·8	85·69	......
18	14-3-12	after 48 hours .	21·06	25·3	83·24	−2·45
19	12-3-12	fresh	19·92	23·8	83·70	......
20	14-3-12	after 48 hours ...	21·89	27·3	80·34	−3·36
21	12-3-12	fresh ...	19·31	23·4	82·50	......
22	13-3-12	Paraffined and analysed after 24 hours.	20·50	24·6	83·37	+0·87
23	12-3-12	Analysed fresh	19·67	23·9	82·31	... ..
24	13-3-12	Paraffined and analysed after 24 hours.	20·92	25·1	89·35	+7·04
25	12-3-12	Analysed fresh	18·98	23·1	82·17	......
26	14-3-12	Paraffined and analysed after 48 hours.	20·17	25·3	79·71	−2·46
27	12-3-12	Analysed fresh	18·08	22·9	78·98	......
28	14-3-12	Paraffined and analysed after 48 hours.	17·38	25·6	67·91	−11·07
		Samples of local Dhaulu. Government Farm, Gurdaspur.				
29	10-2-12	One stool analysed fresh ...	15·53	18·7	83·04	.....
30	11-2-12	No. 29 after 24 hours ..	15·16	18·2	83·30	+0·26
31	10-2-12	Another stool analysed fresh...	14·74	18·0	81·88	.....
32	11-2-12	No. 31 analysed after 24 hours.	14·57	18·2	80·05	−1·83
33	12-2-12	Another stool analysed fresh...	13·68	17·2	79·50	... ..
34	14-2-12	No. 33 after 48 hours (ends of canes cut off.)	15·15	18·5	81·50	+2·00
35	12-2-12	Another stool analysed fresh...	13·55	17·7	73·04	......
36	14-2-12	No. 36 after 48 hours (ends of canes cut off.)	14·50	18·5	77·08	+4·04
37	12-2-12	Another stool analysed fresh ..	13·68	17·2	79·50	......
38	14-2-12	No. 37 analysed after 48 hours (ends of canes not cut off).	14·28	17·6	81·14	+1·64
39	12-2-12	Another stool analysed fresh ..	13·55	17·7	73·04	......
40	14-2-12	No. 39 analysed after 48 hours (ends of canes not cut off).	14·69	18·8	78·14	+5·10

TABLE V.

Special experiment, Government Farm, Gurdaspur.

(*N.B.* Stripping and topping was done in the first week of January 1912 and the analyses were made in the second and third weeks of February.)

No. and date of sample	Description and locality of cane		G	Su	To	G	Sucrose per on total s	Fibre on	Increase or decrease in the sucrose.	rease or de of sucrose otal solids
1 8-2-12	Red Dhaulu stripped and topped on the ground	57·95	0·78	13·95	17·50	5 6	79·71	20·94	-0·57	+1·65
2 ,,	White Dhaulu untouched corresponding to No. 1.	52·57	0·69	14·52	18·6	4·75	78·06	20·6		
3 ,,	Red Dhaulu stripped and topped.	61·76	0·85	14·17	17·6	5·29	80 51	16·68	-0·94	+2·21
4 ,,	White Dhaulu untouched corresponding to No. 3.	59·93	0·79	15·11	19·3	5·23	78·30	15·01		
5 12-2-12	Reddish white Dhaulu stripped and topped.	56·6	0·83	12·95	16·7	6·41	77·5	17·71	-1·49	+0·3
6 ,,	Untouched corresponding to No. 5.	57·4	0·97	14·44	18·7	6·71	77·2	17·29		
7 ,,	Reddish white Dhaulu stripped and topped.	59 0	0·55	13·43	16·9	4·09	79·5	20·05	-2·16	-3·9
	Greenish white Dhaulu untouched corresponding to No. 7	53·8	0·69	15·59	18·7	4 42	83·4	20·02		
9 15-2-12	Reddish white Dhaulu stripped and topped.	53·4	0·10	11·15	15·5	0·89	71·88	13·0	1·08	+1·98
10 ,,	Greenish white Dhaulu untouched corresponding to No. 9.	54·80	0·09	12 23	17·5	0 73	69 9	17·63		
11 ,,	Reddish Dhaulu stripped.	59·7	0·99	12·15	17 1	8·15	71·1	15·92	-1·08	-6·95
12 ,,	Greenish white Dhaulu untouched corresponding to No. 11.	59·9	0·20	13·23	16·95	1·51	78·05	16·98	...	
13 ,,	Red Dhaulu stripped.	54·8	0·20	13·60	16·0	1·47	81·92	18 92	-1·87	+0·12
14 ,,	White Dhaulu untouched corresponding to No. 13.	45·2	0·15	14·47	17·7	1·03	81·8	22·38		
15 16-2-12	Red Dhaulu stripped.	53·2	0·12	13·22	16 9	0·9	78·22	18·49	-1·21	-2·39
16 ,,	Greenish white Dhaulu untouched corresponding to No. 15.	56·5	0·11	14·43	17·9	0·75	80·61	17·29		
17 ,,	Reddish white Dhaulu stripped.	56·9	0·11	13·51	17·3	0·81	78·09	20·26	-1·11	-2·24
18 ,,	Greenish white Dhaulu untouched corresponding to No. 17.	56·0	0·09	14·62	18 2	0·61	80·33	17·97		

TABLE V.—(*Contd.*)

No. and date of sample	Description and locality of cane	Juice per cent	Glucose per cent	Sucrose per cent	Total solids	Glucose ratio	Sucrose per cent on total solids	Fibre on cane	Increase or decrease in the sucrose	Increase or decrease of sucrose on total solids
19 16-2-12	Reddish white Dhaulu stripped	49·2	0·13	14·37	17·3	0·91	83·06	21·84	- 0·74	+ 1·39
20 ,,	Greenish white Dhaulu untouched corresponding to No. 19.	63·1	0·23	15·11	18·5	1·52	81·67	16 61	...	...
21 17-2-12	Reddish white Dhaulu stripped and topped.	54·4	0·60	12·15	15·1	4·94	80·46	20·42	- 1 94	- 0·44
22 ,,	Greenish white Dhaulu untouched corresponding to No. 21.	58·2	0·35	14·09	17·4	2·55	80·9	18·39	..	..
23 ,,	Reddish green Dhaulu stripped.	54·4	0·20	14·79	18·3	1·35	80·82	20·28	- 0·73	- 0·88
24 ,,	White Dhaulu untouched corresponding to No. 23.	58·0	0·19	15·53	19·0	1·22	81·70	20·38	.	.

The analyses given in the above tables were made in 1912. In 1913 a few more observations were made, the results of which are given in the following table.

TABLE VI.

Showing the effect of storing cane on the composition of the sugars.

Storage under ordinary conditions; Diffusion method used for analysis.

Number of experiment and date of analysis		Time of preservation in hours	Initial sucrose per cent on total solids	Final sucrose per cent on total solids	Initial glucose per cent on total solids	Final glucose per cent on total solids	Change in sucrose per cent on total solids	Change in glucose per cent on total solids	REMARKS
1	12-3-13	1	71·7	70·4	1·21	1·22	- 1·3	+0·01	
2	13-3-13	2	71·8	71·2	1·57	1 47	- 0·6	-0·10	
3	18-3-13	2	56·5(?)	68·7	1·22	1 10	+12·2(?)	- 0·12	
4	14-3-13	3	64·8	74·7	2·03	3·17	+ 9·9	+1·14	
5	15-3-13	3	74·7	77·0	2 39	3 49	+ 2·3	+1·10	
6	14-3-13	4	64·8	77·2	2·03	2·96	+12·4	+0·93	
7	17-3-13	5	65 4	76·4	2 28	3·25	+11·0	+0·97	
8	13-3-13	9	71·8	74·7	1·57	1·18	+ 2·9	- 0·39	
9	{ 11-3-13 12-3-13 }	24	69·8	66·5	0·91	0·92	- 3·3	+0 01	
10	{ 12-3-13 13-3-13 }	24	71·7	68·5	1·21	3·45	- 3·2	+2·24	

In Table VI the cane was cut into lengths of one internode, placed in a beaker and covered with a watch glass and analysed after 0, 1, 2, 3, 4, 5, 9 and 24 hours. In five out of ten samples examined the formation of sucrose had continued. It was thought that artificial dehydration of the cane might accelerate saccharogenesis. Samples of *Katha* cane were, therefore, cut into lengths of one internode and preserved in a desiccator over sulphuric acid. In one set of experiments dehydration was preceded by a sterilization of the canes with chloroform vapour. The results obtained are given in the following table.

TABLE VII.

Showing the effect on the composition of the sugars of storing cane under dehydrating conditions.

Number of experiment	Time of preservation in hours	Initial sucrose % on total solids	Final sucrose % on total solids	Initial glucose % on total solids	Final glucose % on total solids	Change in sucrose % on total solids	Change in glucose % on total solids
1	2	67 70	63·60	2·32	1·90	-4·10	-0·42
2	2	76·74	83·28	2·17	1 93	+6·54	-0·24
3	24	69·79	60·70	1 07	0·41	-9·09	-0·66
4	24	68·19	68·08	2·76	2·67	-0·11	-0·09
5	24	65·65	62·92	2·04	1·54	-2·73	-0·50
Dehydration under sterilized conditions.							
6	2	68·19	61·55	2·76	2·62	- 6·64	-0·14
7	18	69·79	65·13	1 07	3·11	- 4·66	+2·04
8	18	67·07	53·22	3·53	4·00	-13·85	+0·47
9	18	67·07	61·46	3·53	3·14	- 5·61	-0·39
10	24	67 70	56 62	2·32	2·50	-11·08	+0·18
11	24	65·64	86·68	2·04	2·74	+21·04	+0·70
12	24	73·41	68·89	2·35	3·18	- 4·52	+0·83
13	24	73·41	66·82	2·35	4·00	- 6·59	+1·65

Dehydration of the cane to the extent effected by such a drying agent as sulphuric acid in a closed vessel has led to a decay of sucrose in every case except two, evidently rapid drying of the cane only results in a destruction of sucrose.

Since all the above experiments had been made on nearly ripe cane, it was thought that perhaps more definite results could be obtained by working on the crop in an unripe condition. The observations were therefore continued in the beginning of the

following September and a number of variations were introduced into the experiment such as paraffining the ends and nodes of the cane immediately after cutting and stripping in the field, or doing this operation in the laboratory perhaps half to one hour after cutting; and storing the cut cane in the laboratory or in cool chambers so as to vary the temperatures at which the canes were stored. This series of experiments commenced on the 9th of September, that is, about 3½ months before the cane harvest. The stored samples were kept in the laboratory after paraffining the ends to prevent excessive loss of water. Average temperature of the laboratory was 85°F.

TABLE VII.

Effect of storing canes in the laboratory on the sucrose and glucose contents of the juice. Kathu canes after cutting were brought to the laboratory and then paraffined. The juice was extracted by a laboratory hand-mill. The canes were divided into two or three exactly similar lots of which one was analysed fresh and the second and third after storage for a definite time in the laboratory.

No. of sample	Date of analysis	Time of storage in hours	Initial sucrose per cent on total solids in the juice	Final sucrose per cent on total solids in the juice	Difference between initial and final sucrose per cent on total solids	Initial glucose per cent on total solids in the juice	Final glucose per cent on total solids in the juice	Difference between initial and final glucose per cent on total solids	Temperature in degrees F. under which storage was conducted
1	9-9-13	6	83·58	81·03	− 2·55	5·12	5·44	+ 0·32	Average 85° F.
2	10-9-13	6	67·51	70·06	+ 2·55	9·50	10·40	+ 0·90	
3	11-9-13	6	77·20	75·79	− 1·41	6·54	5·85	− 0·69	
4	12 & 13-9-13	18	67·06	58·80	− 8·26	7·58	18·70	+11·12	
5	Do.	18	61·13	46·11	−15·02	18·01	29·42	+11·41	
6	Do.	18	65·27	47·96	−17·31	8·12	27·10	+18·98	
7	9 & 10-9-13	24	83·58	77·60	− 5·98	5·12	8·89	+ 3·77	
8	10 & 11-9-13	24	67·51	57·95	− 9·56	9·50	20·06	+10·56	
9	11 & 12-9-13	24	77·20	56·95	−20 25	6·54	23 22	+16·68	
10	15 & 16-9-13	12	81·30	76·35	− 4 95	7·72	10·13	+ 2·41	
11	Do.	12	77·76	75·44	− 2·32	12·12	10·42	− 1·70	
12	Do.	12	79·98	75·75	− 4·23	9·07	10·92	+ 1·85	

The results obtained are given in Table VIII. In every case except one there has been a decay of sucrose. Evidently the reactions affecting the sucrose have been so rapid that in nearly every case the optimum time of storage has been passed.

In the next observations made, the cane was paraffined in the field immediately after cutting and stripping, and stored in the laboratory for a period of six hours only. By this time (20th September) the temperature of the laboratory had fallen to an average of 79°F. Three out of five positive results were obtained showing that sucrose formation was still proceeding.

TABLE IX.

Effect of storing canes for six hours in the laboratory the temperature of which was about 80°F.

No.	Date of analysis	Time of storage	Initial sucrose per cent on total solids of the juice	Final sucrose per cent on total solids of the juice	Difference between the initial and final sucrose per cent	Initial glucose per cent on the total solids of the juice	Final glucose per cent on the total solids of the juice	Difference between the initial and final glucose per cent	Temperature at which the cane was stored.
1	20-9-13	6	79·13	77·70	−1·43	3·63	5·02	+1·39	78°F.
2	Do.	6	74·40	72·21	−2·19	5·18	6·30	+1·12	78°F.
3	22-9-13	6	73·99	74·17	+0·18	5·24	5·33	+0·09	80°F.
4	23-9-13	6	75·60	77·31	+1·71	4·40	3·12	−1·28	80°F.
5	Do.	6	72·96.	73·65	+0·69	5·09	5·17	+0·08	78°F.

As the decay of sucrose in the cane consists of a series of chemical reactions commencing with enzymic hydrolysis the reaction velocity will decrease as the temperature at which the cane is stored falls, provided this is below the optimum temperature for enzymic hydrolysis. As this is about 52°C., we can safely assume that over the range of temperature at which these experiments have been carried out, the reaction velocity will in all these observations follow this law.

The results given in Table IX seem to indicate that we have passed the optimum time of storage for a temperature of 79°F. or in other words after-ripening has taken place and been succeeded by decay though there is still evidence remaining of the formation of sucrose having continued.

With such a variable material as the living plant, it is almost useless to attempt to investigate the reaction velocity of these

changes for in no case could we secure two canes which would give us a juice of the same chemical composition. We cannot at this stage aim at obtaining strict numerical data regarding this point but we should be able to obtain such data as will give us a true qualitative analysis of what takes place.

Taking a six hours' storage at 79°F. as being too long a period for the average *Katha* cane in the condition of ripeness existing towards the end of September, we should be able to raise the number of positive results showing a continuance of sucrose formation if we lower the temperature and keep the time of storage constant. This has been done in the following table.

TABLE X.

Effect of storage of canes in the ice chest (noting the temperature of the ice chest) on the glucose and sucrose contents of the juice. Katha canes were cut from the field and paraffined there at the ends and then brought to the laboratory and analysed after crushing them in the laboratory hand-mill. The canes were divided into two or three exactly similar lots of which one was analysed fresh and the second and third after storage in the ice chest for six hours.

Sample No.	Date of analysis	Time of storage in hours	Initial sucrose per cent on total solids in the juice	Final sucrose per cent on total solids in the juice	Difference between the initial and the final sucrose per cent	Initial glucose per cent on total solids in the juice.	Final glucose per cent on total solids in the juice	Difference between the initial and final glucose per cent	Temperature of storage in degrees F.
1	26-9-13	6	74·50	77·95	+3·45	5·40	4·76	−0·64	71·3
2	Do.	6	73·61	74·53	+0·92	5·21	5·69	+0·48	71·3
3	27-9-13	6	76·35	77·23	+0·88	6·30	5·53	−0·77	65·6
4	Do.	6	76·35	76·91	+0·56	6·27	6 29	+0·02	65·6
5	1-10-13	6	74·20	72·62	−1·58	6·18	6·56	+0·38	61·5
6	Do.	6	78·36	77·47	−0·89	5·96	4·65	−1·31	61·5
7	3-10-13	6	80·45	80·72	+0·27	3·36	3·24	−0·12	70·0
8	Do.	6	78·71	79·09	+0·38	5·00	3·78	−1·22	70·0
9	4-10-13	6	78·02	78·26	+0·24	2·62	3·21	+0 59	66·0
10	Do.	6	77·95	78·19	+0·24	4·54	4·88	+0·34	66·0
11	11-10-13	6	76·29	75·52	−0·77	3·63	2·64	−0·99	63·0
12	Do.	6	75·99	77·19	+1·20	4·15	3·05	−1·10	63·0
13	13-10-13	6	78·70	80·35	+1·65	2·13	2·07	−0·06	61·5
14	Do.	6	78·98	81·52	+2·54	1·80	2·09	+0·29	61·5
15	14-10-13	6	77·48	81·21	+3·73	3·85	3·67	−0·18	56·5
16	Do.	6	82·39	82·50	+0·11	2·18	2·29	+0·11	56·5
17	18-10 13	6	75·58	78·63	+3·07	1·23	2·10	+0·87	65·0
18	20-10-13	6	79·65	77·56	−2·09	2·70	2·90	+0·20	60·5
19	Do.	6	81·62	77·79	−3·83	2·06	1·92	−0·14	60·5

TABLE X.—(*Contd.*)

Sample No.	Date of analysis	Time of storage in hours	Initial sucrose per cent on total solids in the juice	Final sucrose per cent on total solids in the juice	Difference between the initial and the final sucrose per cent	Initial glucose per cent on total solids in the juice	Final glucose per cent on total solids in the juice	Difference between the initial and final glucose per cent	Temperature of storage in degrees F.
20	21-10-13	6	77·67	75·93	−1·74	2·37	2·58	+0·21	57·0
21	Do.	6	77·77	76·82	−0 95	1·82	1·835	+0·015	57·0
22	24-10-13	6	79·85	79·36	−0·49	2·17	2·27	+0·10	55·5
23	Do.	6	76·86	74 45	−2·41	2·69	3·39	+0·70	55·5
24	25-10-13	6	79·16	80·27	+1·11	1·36	1·82	+0·46	56·5
25	Do	6	78·02	79 73	+1·71	1·94	2·07	+0·13	56·5
26	27-10-13	6	79·15	80·25	+1·10	1·59	1·96	+0·37	64·0
27	Do.	6	79·93	78·29	−1·64	1·49	2·03	+0·54	64·0
28	28-10-13	6	81·07	79·92	−1·15	2·04	1·88	−0·16	65·0
29	Do	6	80·46	80·23	−0·23	1·18	1·27	+0·09	65·0
30	30-10 13	6	79·50	78·14	−1·36	1·23	1·73	+0·50	63·0
31	Do.	6	79·35	80·33	+0·98	1·95	1 63	−0·32	63·0
32	31-10-13	6	81·43	85·31	+3·88	1·27	1·95	+0·68	61·7
33	3-11-13	6	76·31	77·83	+1·52	1·64	2·35	+0·71	62·5
34	4-11-13	6	81·35	81·77	+0·42	1·99	0·52	−1·47	62·2
35	5-11-13	6	79·35	83·52	+4·17	1·05	1·74	+0·69	62·7
36	6-11-13	6	78 20	76·71	−1·49	1·51	1·79	+0·28	62·5
37	7-11-13	6	79·75	78·93	−0·82	2·74	2·24	−0·50	60·7
38	8-11-13	6	83·72	81·52	−2·20	1·40	1·57	+0·17	62·5
39	11-11-13	6	81·71	79·40	−2·31	1·04	1·08	+0·04	62·2
40	12-11-13	6	78·85	78·60	−0·25	1·21	2·22	+1·01	61·8
41	14-11-13	6	81·60	78·70	−2·90	0·96	1·95	+0·99	62·5
42	15-11-13	6	67·44	76·60	+9·16	1·39	0·77	−0·62	61·9
43	17-11-13	6	80·17	84·35	+4·18	0·80	0·88	+0·08	60·5
44	18-11-13	6	81·77	83·01	+1·24	1·14	1·29	+0·15	60·0
45	19-11-13	6	78·14	82·94	+4·80	0·64	2·90	+2·26	59·7
46	22 11-13	6	86·34	81·69	−4·65	1·53	1·65	+0·12	48·0
47	24-11-13	6	76·50	81·60	+5·10	1·78	1·62	−0·16	48·5
48	26-11-13	6	77·80	83·10	+5·30	1·63	2·21	+0·58	48·5
49	1-12-13	6	81·40	80·10	−1·30	1·62	1·38	−0·24	49·5
50	3-12-13	6	78·80	81·60	+2·80	0·96	0·92	−0·04	48·0
51	6 12-13	6	83·20	81·80	−1·40	1·52	1·29	−0·23	49·0
52	10-12-13	6	82·80	80·50	−2·30	0·73	1·14	+0·41	53·7
53	15-12-13	6	82·74	81·48	−1·26	0·72	1·47	+0·75	47·7
54	16-12-13	6	79·15	77·24	−1·91	1·90	0·92	−0·98	47·9
55	17-12-13	6	77·84	74·49	−3·35	0·93	1·08	+0·15	57·5
56	19-12-13	6	82·74	81·79	−0·95	0·863	0·856	−0·007	47·0
57	20-12-13	6	78·63	81·72	+3·09	0·90	0·88	−0·02	61·5
58	22-12-13	6	78·86	82·24	+3·38	0·91	0·73	−0·21	52·0

One of the principal difficulties in carrying out the analysis is that only one or two complete observations can be made each day and every day that passes is changing the composition of the cane, for this is getting riper. This is one of the reasons why concordant numerical results cannot be expected. Thus for example in Table X, storing of cane for six hours at a temperature of 65°F. gave fairly concordant results on the 27th September but quite different results were obtained for the same time and temperature with cane cut on the 18th of October, three weeks later.

Summarizing these results, it is evident that there is a scientific foundation for the custom practised in the Gurdaspur District of storing cut cane before crushing as this tends to further ripening. From the observations recorded above, it is clear that this is attended with danger of losing sugar if the storing is continued for too long a period.

The length of time for which cane can be stored without suffering a loss of sugar, and during which an actual increase in the amount of sugar in the juice will take place, will vary with the temperature of the air and the condition of the cane. This period will become shorter as the temperature rises. Excessive cold on the other hand, including too great a change in temperature, may also bring about losses in sucrose probably owing to suspended activity of the cell protoplasm and resulting in a loss of control of the ordinary fermentation changes normally taking place there.

The Java system of covering cut cane with damp trash is to keep the cane stem alive. By this treatment the cane will be maintained at a uniform temperature and being in a moist atmosphere will not lose water. For a limited time, depending on the temperature and condition of the cane, there should be an increase rather than a decrease in the sucrose contents of the cane. On the other hand moist heat will not only induce the growth of moulds, fungi, and bacteria all of which bring about decay fermentation changes, but will, once the cell is dead, induce rapid decay in the cell contents by hydrolysis and oxidation.

The after-ripening of cane is a matter of some importance to the factory owner who may at any time be forced to store cut cane owing to a breakdown in the mill, and the chemical changes outlined above will probably be of interest to him as well as to the student of the chemistry of sugar.

RURAL EDUCATION IN ITS RELATION TO AGRICULTURAL DEVELOPMENT.*

BY

D. CLOUSTON, M.A., B.Sc.,

Deputy Director of Agriculture, Southern and Western Circles, Central Provinces.

In the West the science and art of education have been much developed of late years: the science has been greatly enriched by the writings of such psychologists as Spencer, Bain, James, Adams, and others. Chairs of education have been established in some of our universities. The great reforms in the methods of education, as now practised, owe much to the teachings of the educationists of the sixteenth, seventeenth, and eighteenth centuries. In the latter half of the sixteenth century Montaigne condemned the pedantries of the schools which, he said, exaggerated memory while they depreciated the value of useful knowledge. Ratke and Comenius of the early seventeenth century also denounced the purism of the schools, in which so-called culture and scholarship were synonymous with ability to deliver elegant speeches in the dead languages. The latter was one of the first to lay it down as a principle that the teaching of words and things must go hand in hand. He was, moreover, one of the first advocates of the teaching of science in schools and his method of teaching a language was to teach it as the mother tongue is taught, *viz.*, by conversation on the topics of everyday life. Teaching, he said, should be made interesting by bringing the child into contact with actual things and the pupils should always be kept interested, cheerful, and happy. Locke in the end of the seventeenth century developed Montaigne's theories

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still further: he laid great stress on the training of the mind in order to fit a man for the duties of the world. The aim of education was, he said, to produce a sound mind in a sound body. Rousseau in the eighteenth century wrote his *Emile:* the influence of its revolutionary philosophy was enormous. The child, he said, must be a pupil of Nature. His Emile was taught by the real things of life, by observation and experience: he was to learn nothing from books, much by experience having read deeply in the book of Nature. Like Locke he laid great stress on the physical development of the child and on training his hand and eye. The strength and body of his Emile was to be fully developed: and he was to be athletic and good at handicrafts. Pestalozzi in the latter half of the eighteenth century still further developed and practised the science of education on more or less the same lines. Like Comenius, Locke, and Rousseau he followed Nature: the child's powers of observation had to be developed by training and his whole mind was to be gradually moulded by sympathetic contact with that of the teacher. Sympathy was all important in his method. Froebel, the mystic and disciple of Pestalozzi, like Comenius, looked at the course of Nature for the principles of education. The duty of the pedagogue was, he said, to superintend the development of inborn faculties and to encourage self-activity in the child. Just as the farmer provides good cultivation and leaves the plant to grow naturally, so must the pedagogue give the mind of the child scope to develop. This consists in giving the child opportunities to live, act, and conceive, and at every stage of mental development the child must be cared for as the cultivator cares for his gradually developing plant. In his kindergarten (garden for children) he laid great stress on every child cultivating his own plot of ground: "to give them employment in agreement with their whole nature, to strengthen their bodies, to exercise their senses, to engage their awakening minds, and through their senses to make them acquainted with Nature and their fellow creatures," was to him the essence of true education. Of later day educationists it will suffice if I mention Spencer. To him science was the worthiest subject of study. The child should be trained in things in which it is interested, he said.

The teacher's duty is largely to keep in sympathetic touch with the child and to foster its interest in natural things and to allow it to learn by the experiences of life—this being the way in which the young mind is developed.

Froebel has done perhaps more than any other for the progress of the science and art of education. His kindergarten system for young children has on its own merits become almost universally popular as a method of teaching in the primary school. To the same system can be traced the origin of school gardens as a means to Nature study.

At Home the study of education both as a science and an art has risen into great importance. Chairs of education have been founded in our Scotch Universities at least, where the subject is included in the curriculum for the M.A. degree. Training centres, where the method of teaching is taught, have also been organized at several centres. As a result of all this, a great advance has been made of late years in raising the standard of teaching. The general trend of the new system has been to brighten school life. The system of rote-learning by which the child mastered pages of geographical n mes, historical dates, and rules of grammar has disappeared. New subjects have been added to the school curriculum with a view (i) "to train the young child to observe carefully and to reason correctly from the observations which he makes, (ii) to train the hand and eye to thoroughness by using them in doing things, and (iii) to foster such wholesome outdoor interest in the things of Nature which lie around him as will get him into the habit of approaching the Unknown in a spirit of intelligent curiosity."

These new principles of education aim at the development of the child's intelligence by training him to observe and reason accurately. To give him manual skill and quickness of eye he is trained to do things for "the child must be induced to take as keen an interest as possible in his work and this is usually most easily achieved by means of exercises that lead to tangible results." The child gets his ideas from concrete objects which are familiar to him and which he can handle. In his Nature knowledge lesson he no longer relies on books and pictures but on real objects. Each

school has its little museum in which these are kept. He is trained to appreciate varying shades of form and colour by drawing and colouring figures with the originals in front of him. He draws from a real leaf, not from a line drawing of one. He mixes his own colours to get the shades required, and greets with unfeigned pleasure the discovery that yellow and blue when mixed give a green. The success obtained is very largely dependent on the fact that ample measures have been taken to train the teacher. At the university he studies the science and history of education; at training centres he is taught the art of teaching; and at other centres he learns his kindergarten, his Nature knowledge, and art subjects for schools. A perfect system of classes for teachers has been organized, and elementary teaching has become a highly specialised profession. In towns these meet after school hours or on Saturdays. Rural teachers on the other hand attend central classes during their holidays.

I have briefly outlined the method of teaching which has been evolved in the West with the view of showing the enormous difficulties which have to be overcome before similar methods can be carried out here with any degree of success. I have discussed this subject with some Inspectors of Schools, more especially that part of it which refers to school gardens. Their views are pessimistic on the whole. They have not had the opportunity of specializing in teaching on the lines which I have described: their work is almost entirely administrative, and there are so few of them that they are not in a position to give any new system of education that amount of supervision which would be absolutely necessary in its initial stages. The general opinion seems to be that in the ordinary primary school the difficulty of teaching the child a little of the three R's, in the three or four years during which he attends school irregularly, is in itself a heavy task. They have not yet got qualified teachers nor the required appliances for teaching Nature knowledge properly. School gardens have been established in most of the schools in the Central Provinces and in nearly half those of Berar; but they are not of much educative nature: they are maintained almost entirely for ornamental purposes.

The method of teaching in school which is practised is akin to that which has been condemned by educationists from the sixteenth century downwards. The child is taught mere words, not things: his memory is exercised, while his intelligence is left undeveloped.

I have inspected a good many of these gardens. They are on the whole fairly well kept and do undoubtedly serve a distinct purpose in so far as they help to brighten school surroundings and to give the child and his parents some idea of neatness, order, and beauty: but apart from that they are, under present management, of very little practical value as a means of education. The hardier annuals are grown with a few country and English vegetables; there is very little variety. In one school garden which I visited lately, I found English cabbages and bananas growing, the seedlings of which had been obtained from our Agricultural Assistant; but they were suffering for want of water as the boys were reported not to be willing to draw water from the village well; and the *chowkidar* who ought to have done this work had also refused to do so. In other schools, too, I have found that the question of water supply is one that gives much difficulty in the management of school gardens. The parents are said to object to their children becoming "hewers of wood and drawers of water." The teachers are mostly of non-cultivating castes who have a natural prejudice against doing gardening or any other form of manual work, and are not therefore of the stamp likely to inculcate into the mind of the child a sense of the dignity of labour.

The equipment required for utilizing the educative advantages which school gardening is supposed to supply is still very inadequate in these provinces. This is not surprising when the facts already stated are taken into consideration; moreover, this branch of education is a comparatively new one even in the West. The subject of garden teaching in the curriculum of rural schools at Home only received official recognition within the last twenty years, and not before there was a trained staff of specialists qualified to teach this and other branches of hand-and-eye training. The value of school gardens when properly conducted can be considered under two heads: (*i*) educative, and (*ii*) utilitarian.

Under proper management their educative value is very great. Such teaching makes the school work more concrete. The child can be taught to make a line drawing showing the division of the garden and its different plots. He can be taught the elements of calculation in measuring the size and out-turn of a plot and in reckoning the out-turn and profit per *bigha* or acre therefrom. Gardening can thus be correlated with other branches of school work. The child is trained in the observation of living and therefore interesting things which are changing from day to day. He makes his own observations and is trained to reason correctly from them. The responsibility of having to do things with his own hands makes him practical and resourceful. In carrying out the practical operations in the presence of the teacher and other class-fellows he is taught the dignity of labour and he gets a hand-and-eye training in the use of tools ; he learns by doing things. If properly directed, an intelligent curiosity in his attitude towards Nature is created within him, and he becomes more and more anxious and able to find things out for himself. The attainment of this intelligent and sympathetic attitude towards his natural surroundings and this desire to solve their mysteries should be the main object in view in gardening as in other branches of Nature study. This ideal is a high one, but I feel sure that if we are to rely on our present untrained Indian teachers to carry it out, failure is certain. Such aimless work as is being done at present, discredits the whole movement towards practical education. It is a premature attempt to graft a new and advanced system of education on to a primitive one by the help of teachers who have not yet been trained in the new system and who are therefore quite unqualified.

School gardens could not under present conditions be made of much practical value. But the great desideratum at present is to get teachers trained in the method of teaching Nature study for which the school garden is only a means to an end, and I am of the opinion that to do this successfully it would be necessary to employ a specialist who has fully qualified himself in the science and art of teaching at Home and could be relied upon to turn out teachers qualified in the method of teaching, for Nature study is

largely a method of teaching. It is for the Education Department to decide whether it would be better to do this or to train one of their own men. A two years' training at Home would probably suffice. He would be entirely responsible for the teaching of Nature study, drawing and kindergarten in the Training Colleges. Acting teachers would come there for holiday courses. The specialist would have a model school garden and a museum at each training centre and would frequently take his students out into the fields to study the geology, the *flora* and *fauna* of the country. Manual training including kindergarten and art subjects suited to local conditions, would be taught at the same time. One of his first duties would be to prepare a set of lesson sheets suitable for the provinces : another important task would be the preparation of a Science Reader for the use of middle schools in co-operation with members of the Scientific Departments of the Administration.

The student would learn how to manage a model school garden and how to utilize it as an object-lesson. Each student would have a separate plot of at least one-twentieth of an acre which he should cultivate with his own hands. In addition to this there would be a communal garden area used more epecially for common teaching purposes. Given teachers trained in this way it would then be possible to make existing school gardens of considerable educational value. But the teacher would not depend entirely on the school garden : he would also take out his boys into the fields to study Nature on a larger and more varied scale there.

If taught in this way Nature study would necessarily give the child an interest in agricultural subjects as the teaching would be in the concrete and the object-lessons would nearly all be connected with agriculture. On these lines the perceptive, reflective and reasoning faculties of the child's mind would be developed and it would not be too much to expect that the training acquired in this way while at school might be of the greatest practical value in after-life.

I am well aware of the fact that any great improvement in the quantity or quality of rural education in India must be of slow growth as was the case in England, where we first developed our

industries and thereby enriched the country before evolving that high standard of rural education which we enjoy to-day. Our Government first raised the economic condition of the people and then taxed them heavily for the support of education. In India there is a crying need for more and better rural education among the educated classes at least; but these same classes attach as yet but little importance to the training of the ryot in improved agricultural methods which would enable him to rise in the economic scale. They do not yet fully realize the fact that to create in him that spirit of enterprise, self-reliance, and resourcefulness which are so essential to success in agriculture his education even in the rural school must be made more practical than it is at present.

It is a well known fact that much of the education given in rural schools at present is compulsory in nature though not in name. But for the pressure exercised by Government officials in securing attendance, many of our village schools would stand empty. For the average ryot education has no charms because he does not see its advantages. For those of the clerical class the case is of course quite different. For this class education is absolutely essential to fit them for their life's work. The ryot does not see that agricultural prosperity is in any way dependent on education. This is, I consider, a very strong argument in favour of the steps now being taken by Government to develop Indian agriculture. The development of this, our greatest industry, should precede the development of rural education. If we first demonstrate to the ryot that improved methods bring him prosperity, it will then be an easy matter to prove to him that to enable his boys to benefit to the full from these improvements education is indispensable.

DRIAGE.

THE LOSS IN WEIGHT OF CROPS AFTER HARVESTING.*

BY

G. EVANS, M.A.,

Deputy Director of Agriculture, Northern Circle, Central Provinces.

THE loss of weight of crops during storage is often considerable and is a point that does not seem to have received the attention it deserves when crop experiments are being conducted.

It is highly probable that in some cases the high out-turns reported from agricultural stations do not represent the true marketable weights of the crops obtained and that considerable reductions would have to be made in the out-turns and consequently in the profits per acre shown, if due account was taken of the losses in weight due to driage.

This point is also one of considerable importance to the Revenue Authorities.

In the Central Provinces a series of crop experiments are carried out in each district with a view to obtaining a reasonable idea of the average out-turns of staple crops in each year.

These experiments are personally conducted by the higher Revenue officers of the district. The annual returns of crop experiments are submitted to the Director of Land Records each year. The objects of these crop experiments are firstly to test the incidence of assessments made during Settlement by an independent calculation of the out-turns, and, secondly, to test the correctness of the formulæ on which the crop forecasts are based.

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The Local Administration also prepares a quinquennial statement on the crop-cutting experiments carried out during that period and submits it to the Government of India. From the figures so obtained from the various provinces, a return of the average yield pèr acre of the staple crops of India is compiled for the information of the Secretary of State.

Crop experiments are therefore of considerable importance, and in order that reliable data may be obtained it is absolutely necessary that they should be conducted as accurately as possible.

There are various reasons why these crop experiments are not so accurate as is desirable but in this article I intend only to consider the error which may be introduced by neglecting the factor of driage.

When examining an annual return three years ago for the first time the writer noticed that the yields recorded for light paddy from two districts seemed extraordinarily high for the season which was not a particularly favourable one for this crop. It seemed likely that many of these crops were weighed wet and accordingly another column was inserted in the form to indicate the time that had elapsed between harvesting and weighing. In the following season's return it was noted that in most of the experiments recorded in the returns the crop had been cut and weighed within four hours and in a large number of cases within one hour.

Again an examination of the crop experiment returns for 1915-16 from the nine northern districts of this Province showed that eight experiments had been made on paddy, and that in every case the crop had been cut, threshed, and weighed within 24 hours. Twenty-six experiments had been made on *juar* (*Andropogon Sorghum*), which is a staple *kharif* crop in many parts. Of these five had been cut, threshed, and weighed in 24 hours or less and the remaining twenty-one experiments within six days.

The District Officer is, nowadays, an exceedingly hard-worked individual. He seldom has time to halt for more than one day in a village and can, as seldom, return to the same village if he wishes to complete the experiment. Nevertheless this point represents a considerable source of error and consequently is worthy of attention.

A series of experiments were consequently carried out last year on the Government experimental stations at Hoshangabad and Jubbulpore in order to throw more light on the matter.

The experiments on *kharif* crops were mostly carried out at Jubbulpore and those on *rabi* crops at Hoshangabad.

The procedure adopted was to cut a portion of the crop as soon as it was deemed ripe according to local ideas and carry it as quickly as possible to the threshing floor, the time taken being from two to four hours. The crop was then threshed by hand and about 100 lb. weighed out. The crop was then spread out in a *gur*-boiling pan, in the sun, on the threshing floor and was carefully watched to prevent loss from birds, squirrels, etc. It was weighed at the end of three hours and again after 24 hours and finally at the end of three days. At night the pan containing the crop under experiment was covered with a cloth to keep off the dew.

The various operations are summarized in each statement in the following manner :—

1. Commencement of harvest.
2. Arrival on threshing floor.
3. Completion of threshing.
4. Weight after three hours' drying.
5. Weight after twenty-four hours' drying.
6. Weight after three days' drying.

Experiment I.—Kadamphool, a light paddy.

Operation No.	Date	Hour	Weight lb.	Loss of weight	REMARKS
	6-11-1915	7	...	...	
	Do.	9	...	..	
	Do.	13	100	...	100 lb. weighed out
	Do.	14	95½	4½	Three hours.
	7-11-1915	16	90½	5	One day.
	9-11-1915	16	86¼	4¼	Three days.

The total loss of weight in three days is 13·75 per cent.

There was a little dew on the crop when it was harvested but this had probably all evaporated before the first weighment was made.

Experiment II.—Basmatia, a light paddy.

Operation No.	Date	Hour	Weight lb.	Loss of weight	REMARKS
1	13-10-1915	8·00	...	..	
2	Do.	10·55	...	...	
3	Do.	14·30	100	...	
4	Do.	17·30	$98\frac{1}{2}$	$1\frac{1}{2}$	Three hours.
5	14-10-1915	17·00	93	$5\frac{1}{2}$	One day.
6	16-10-1915	17·00	$88\frac{1}{4}$	$4\frac{3}{4}$	Three days.

Loss in weight=11·75 per cent.

Experiment III.—Haradgundi, a medium paddy.

1	25-11-1915	7·00	.	...	
2	Do.	9·00	.	...	
3	Do.	13·40	100	...	
4	Do.	6·40	96	4	Three hours.
5	26-11-1915	6·40	$92\frac{1}{2}$	$3\frac{1}{2}$	One day.
6	28-11-1915	6·40	$88\frac{1}{2}$	4	Three days.

Loss of weight=11·5 per cent.

Experiment IV.—Dilbuxa, a late paddy.

1	4-12-1915	8·00	...	...	
2	Do.	12·00	...	..	
3	Do.	16·00	100	...	100 lb. weighed.
4	Do.	17·00	$99\frac{1}{2}$	$\frac{1}{2}$	One hour only.
5	5-12-1915	11·30	95	$4\frac{1}{2}$	......
6	7-12-1915	11·30	$90\frac{1}{2}$	$4\frac{1}{2}$	Rather less than 3 days.

The crop was dead ripe. Loss of weight in less than three days=9·5 per cent.

Experiment V.—Gurmatia, a very late paddy.

1	9-12-1915	7·00	...	..	
2	Do.	12·00	...	...	
3	Do.	17·00	107	.	107 lb. weighed.
4	10-12-1915	13·20	$104\frac{1}{2}$	$2\frac{1}{2}$	
5	11-12-1915	13·20	102	$2\frac{1}{2}$	
6	12-12-1915	13·20	100	2	Three days.

Loss of weight is equal to 6·5 per cent.

The results of these experiments in paddy show that there is a considerable loss in weight in three days due to driage and that this loss is greatest in the light rices which are cut and harvested in October and November when there is a good deal of moisture in the air and evaporation is less rapid. The practice of harvesting and weighing rices for the purpose of crop experiment returns in the space of three hours may therefore easily lead to an error of 10 per cent over the true out-turn of crop, and this is also probably true for *kodon* and other of the minor millets.

Experiments with ground-nuts.—Similar experiments were carried out on ground-nuts, a crop which is beginning to come into favour in some parts of the Central Provinces.

The Big Japanese variety, which is a loose husked kind, showed a loss in weight of no less than 43 per cent in eight days, of this 41½ per cent loss in weight was registered in the first six days.

Small Japanese ground-nut, a small tight skinned variety, showed an even greater loss, *viz.*, 46½ per cent in six days.

Experiment on juar (*Andropogon Sorghum*).—This experiment was carried out on the Hoshangabad Farm on 8th December 1915. The crop was harvested fully ripe and threshed by hand from 9 to 12 A.M., cleaned and winnowed from 1-30 to 3-30 P.M., and 100 lb. grain weighed out at 3-30 P.M.

			Lb.	Oz.
The weight after	3 hours	...	99	8
Do.	24 ,,	...	93	11
Do.	3 days	...	85	4
Do.	2 months	...	77	12

The loss in weight, therefore, was nearly 15 per cent at the end of three days and more than 22 per cent after two months.

Experiments with rabi crops.—As might be expected *rabi* crops on the whole show little loss due to driage. They are nearly always harvested dead ripe and at a time when the air is very dry and the temperature high.

Maghai til (*Sesamum indicum*).—A variety which is extensively grown as a *rabi* crop in the lower Nerbudda valley and is harvested in January and February showed a loss in weight of 3 per cent after three days.

Gram (*Cicer arietinum*).—Cut dead ripe, a loss of only 1 per cent.

Wheat.—Pissi wheat lost only 2 per cent, Dahutia and Bansi (Durum wheats) 2½ and 2¾ per cent respectively, the latter being an irrigated crop.

CONCLUSION.

There is a considerable loss of weight on storage of *kharif* crops.

In the case of paddy the loss due to driage may be as much as 14 per cent. Light rices which are cut in September and October at the close of the monsoon when the air is full of moisture, lose

more weight than the heavy rices which are cut later on after the cold weather has commenced and the air is drier.

Juar also loses weight considerably. The loss of weight in *rabi* crops is practically negligible as they are usually cut dead ripe at the beginning of the hot weather when the air is intensely dry and evaporation is rapid.

Further experiments are being conducted as it may be possible to arrive at some rough factor which will allow of suitable deductions being made for driage for the different staple crops.

A NOTE ON DOURINE IN THE HORSE.*

BY

COLONEL H. T. PEASE, C.I.E., V.D., I.C.V.D.,

Principal, Punjab Veterinary College, Lahore.

(Continued from page 78, Vol XII, Part I.)

Early symptoms in the stallion. As the disease is contracted by coitus the trypanosome gains entry through some abrasion of the mucous membrane of the penis and multiplying at the seat of entry sets up some slight irritation of the tissues, resulting in a collection of lymph there, so the primary symptom consists in the appearance of some œdematous swelling of the penis and in the neighbouring parts. There is little doubt that this symptom always appears but it is so variable in amount that at times it is so little that it may escape notice. Generally, however, it is easily seen and in some cases is considerable, involving the prepuce sheath and in some cases scrotum as well, and in a few cases may extend under the skin of the belly towards the chest.

It appears in from 10 to 30 days after an infective covering.

The parasite appears to grow in crops in the tissues near the seat of inoculation and as a result of this the amount of œdema present varies considerably from time to time as the parasites are few or numerous.

What generally happens is that the primary œdema disappears after a time and remains absent for a few days when it again reappears.

* Received for publication on 16th November, 1916.

As a result of the multiplication of the parasite in the tissues there is some slight irritation in the organ. The horse is uneasy and is constantly drawing and retracting it.

The result of the recurrence of œdema in the parts is that by degrees lymph becomes organized into fibrous tissue there and after about a month the sheath becomes permanently swollen and is doughy to the touch.

The trypanosome seems to greatly prefer the lymph-bathed tissues to the blood and it attacks or rather injures the lymphatic system. Travelling along the lymphatics it reaches the neighbouring lymphatic gland and this generally becomes enlarged early in the attack.

The urethra is in some cases involved in which case it will be slightly inflamed and sooner or later protrude somewhat and be red in colour. In such cases the passing of urine may be attended by some pain.

In the early stages of the disease, when the amount of œdema is small, and there are no constitutional symptoms of disease at all, it is very difficult for any one to realize that there is anything really seriously wrong with the horse as his coat is glossy, condition good, appetite normal, and temperature generally within normal limits.

This is a most unfortunate circumstance because it is at this time that the horse will generally, freely and easily cover a mare and it is also at this time that he is most infective. The horse is, consequently as a rule, kept at work and nothing much is thought of the condition.

This œdematous swelling may in some cases be the only symptom noticed for some months and if during all this time the horse is kept at work it will be easily understood that considerable damage will be done.

As a rule, however, in carefully observed cases in India, especially in imported animals the parasite gains the general circulation, probably by way of the lymphatics. It does not appear, however, to like the blood very much and does not seem to multiply in it. It is practically impossible to find any trypanosomes in the blood of the general circulation at any period of the disease, and

the only proof we can adduce of its presence there is the fact that we can generally reproduce the disease in a susceptible animal by inoculating it with a large quantity of blood from a diseased animal. The entry of the parasite into the blood causes no fever.

What does, in most cases however, occur is that a few parasites escape from the cutaneous capillaries into the tissues and multiplying there or setting up irritation give rise to a peculiar eruption on the skin in the shape of flattened œdematous patches or plaques.

Early symptoms in the mare. The infective material in the mare gains entry into the mucous membrane of the vagina and multiplies there, giving rise to inflammation and œdema in the same way as in the horse. The parasite sets up irritation in the mucous membrane and as the clitoris is generally involved the mare is uneasy, whisks her tail and appears to be in season and this is often the first symptom seen. This is a most unfortunate circumstance as the owner, naturally suspecting nothing wrong, generally takes her again to a stallion and as trypanosomes are at that time numerous in the vaginal membrane there is considerable chance of her infecting him. Cases are on record in which congestion and œdema of the vaginal mucous membrane are the only changes noticed for six or seven months—a most dangerous state of affairs.

Generally, however, the œdematous swelling involves one or both lips of the vulva. The swelling may be very slight and scarcely noticeable or it may extend to the perineum or even to the mammary gland.

If the mucous membrane of the vagina be examined, parts of it will be found congested and œdematous. These are red at first and later reddish violet. The clitoris is generally congested and irritated in an erect position and this causes the mare to rub her rump and tail against the stable wall. In some cases small ulcers appear on the membrane but they are not constant and soon heal up. Mucous discharge generally escapes in small quantity from the vulva but the quantity and quality of this vary considerably. In some cases it is scarcely perceptible, in others it is viscid dirty white in colour and soils the tail, perineum and thighs.

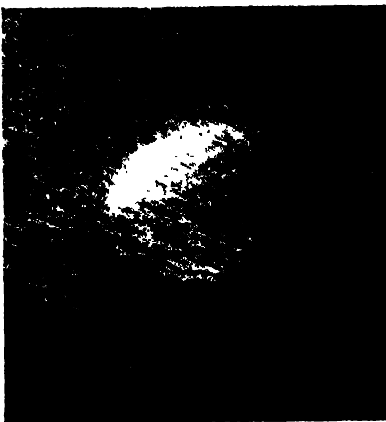
As is the case with the local lesions in the horse the swellings increase and decrease but eventually the elasticity of the tissues of the vulva is lost, fibrous tissue develops in it and the organ becomes deformed, flaccid, wrinkled, gaping at the lower extremity and showing the congested clitoris. This is the condition often seen in old cases in which, in addition, patches of white tissue due to destruction of pigment, will be seen on the skin of the vulva.

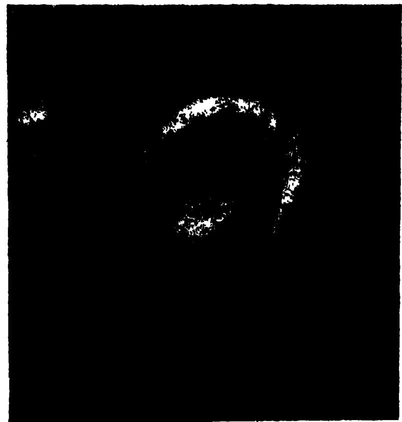
These then are the early symptoms in the mare and they may remain throughout the disease. The parasite goes on multiplying there in crops and soon gains the general circulation and in the same way as in the horse, gives rise to a patchy eruption of the skin.

Eruption of patches. In regard to the eruption of these patches they are the same in both horse and mare, so we may consider them together.

What generally occurs in carefully observed cases in India is that in from 25 to 60 days after the infective covering a peculiar patchy eruption appears on the skin.

In Lingard's cases after covering in five mares the first plaque appeared in 30, 32, 24 and 33 days respectively, while in the fifth it was 116 days. In two inoculated mares plaques appeared in one case in 34 days and in the other in 70 days.





Well-marked patches on skin—Lingard.

In my original cases it was 34 and 36 days.

As has before been said the skin eruptions vary very considerably in number and size. In some cases the plaques are very few and so small as to be discovered with difficulty, it being necessary to look along the skin towards the light to see them at all. In such cases there is just the faintest layer of œdema in the skin and the hair over it lies unevenly. Such plaques are easily overlooked; as a rule, however, the plaques are large and seen in considerable number. They are generally circular patches of œdema, flat or slightly oval on the surface, but they may be irregular in shape. They vary very considerably in size from ½ to 5 inches in diameter but irregular-shaped ones may be even larger.

These plaques may appear singly and at long intervals or several appear within a period of 12 to 24 hours.

The circular plaques are generally only slightly raised above the surrounding skin. Each plaque, in the great majority of cases, appears but once and after persisting for a variable time disappears slowly or suddenly. The time which they remain varies from 1 to about 40 days. They generally only remain for a short time. These plaques are due to the trypanosome becoming localized in the tissues and setting up slight lymphangitis and consequent œdema.

In the second phase of the disease then we have the symptoms connected with the genital organs and in addition, these peculiar patches on the skin, and such symptoms are diagnostic.

The newly erupted patches invariably contain the trypanosome in greater or lesser numbers. The eruption of patches during the course of the disease continues for a variable period in some recorded cases for 75 to 313 days, in the horse. In a thorough-bred stallion they continued 313 days.

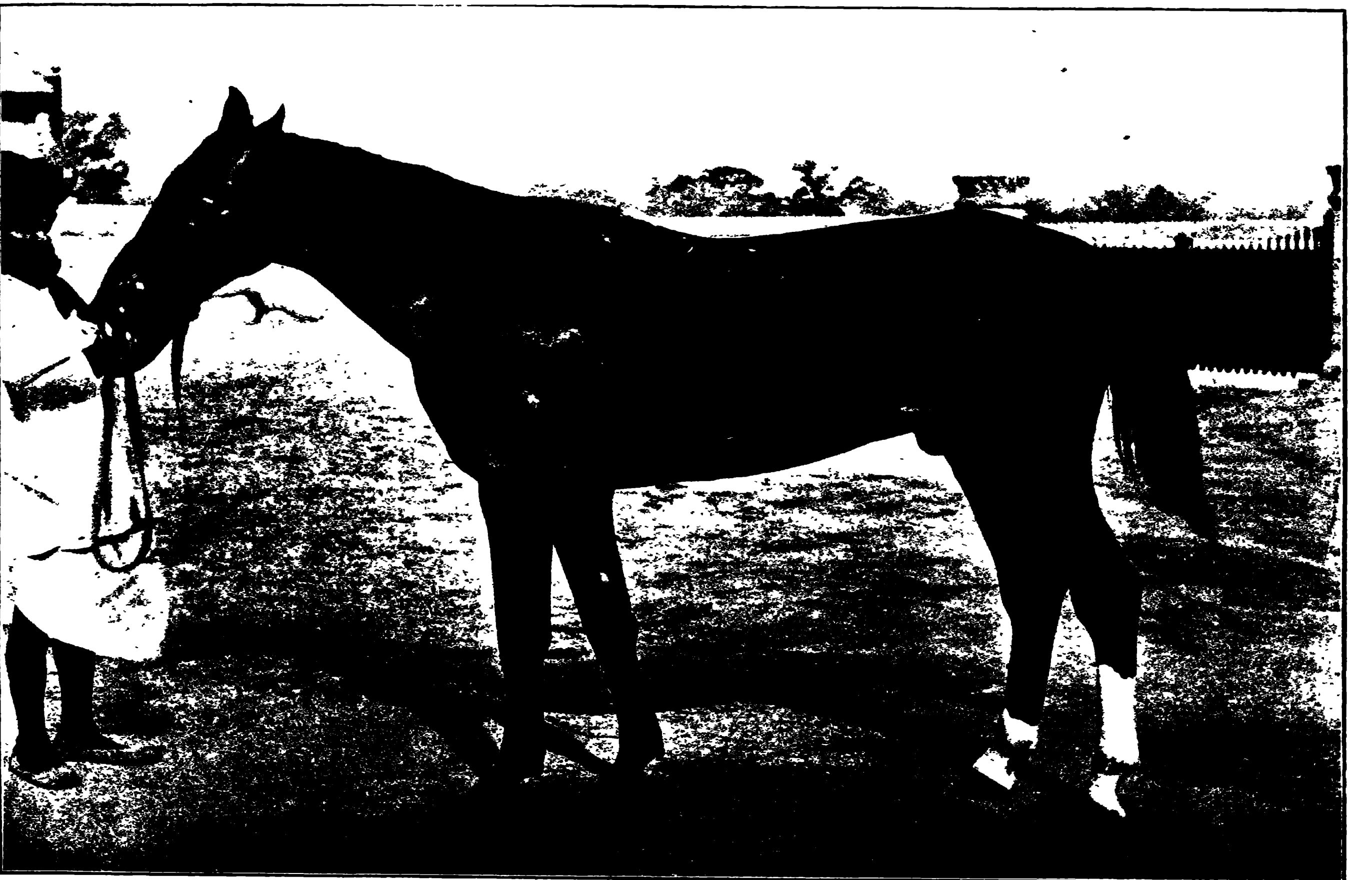
The following periods have been noted :—

	Days
Arab stallions	254-304
Australian mares	168-202
Country-bred mares	75-181

The time varies then in different animals, being shortest in country-breds and longest in English thorough-breds.



PLATE VIII.



Showing slight swelling of sheath and penis and bad condition.

The eruption of plaques is generally greatest early in the course of the disease and at this time in well-marked cases the body is seldom entirely free from them for any length of time.

As the disease progresses they become fewer and eventually long intervals elapse during which no plaques appear and the disease seems to make no progress.

In some cases months may elapse between the patches. Lingard quotes a case in which the interval was 138 days or 4½ months, and this coincides with my own experience. In very old cases patches apparently cease to occur.

At a later period other skin lesions appear at the seat of the œdema, testicles, scrotum, vulva, perineum in the form of leucoderma or white spots due to destruction of the skin pigment by the trypanosome. Attacks of urticaria are common in this as in other parasitic diseases and the eruption generally lasts only for a short time.

In regard to the further progress of the disease the eruption of plaques on the skin and the local symptoms continue for many months in most cases and concurrently other general symptoms develop.

There can be no doubt that the trypanosome produces toxic material, for attacks of urticaria due to it are often seen on the skin during the course of the malady.

This toxin exercises an adverse influence on the bodily functions and as a result the animal loses spirit and condition, the coat becomes harsh and unhealthy and the animal spends a good deal of its time lying down.

The further progress and complications which may occur, seem to depend on the localization of the parasite in some particular tissue.

Like other trypanosomes the parasite often cultivates in the spinal cord. When this happens it is generally in fairly bad cases and symptoms of weakness of the hind quarters and paralysis occur. These vary considerably in degree. They may be confined to feebleness of the hind quarters; the animal frequently resting its hind limbs alternately or if walking, dragging them forward in a listless manner.

In other cases the hocks and pasterns suddenly give way.

In other cases the paralysis may suddenly appear without any previous indication and the animal falls and is unable to rise.

These paralytic symptoms do not occur in all cases. Maresch in Bohemia states that the malady may run its course without any symptoms of paralysis showing themselves but that paralysis cannot be present in Dourine without being accompanied, or at least preceded, by the characteristic lesion of the generative apparatus. At the time when paralysis usually shows itself the other local lesions may be few and not marked or even in abeyance and may reappear later on and lead to the supposition that they are secondary and not primary symptoms.

The paralytic symptoms may disappear in some cases. In others, however, they increase and complete paralysis results. In such cases emaciation becomes great and death results.

Other complications are not at all uncommon. Early in the disease the trypanosome invades the lymphatics and sets up irritation in them and especially in the lymphatic glands so that these are found to be enlarged in many parts of the body. The parasites often cause suppuration and abscess formation in the lymphatics and especially in those situated in the region of the scrotum of the horse and the mammary gland of the mare.

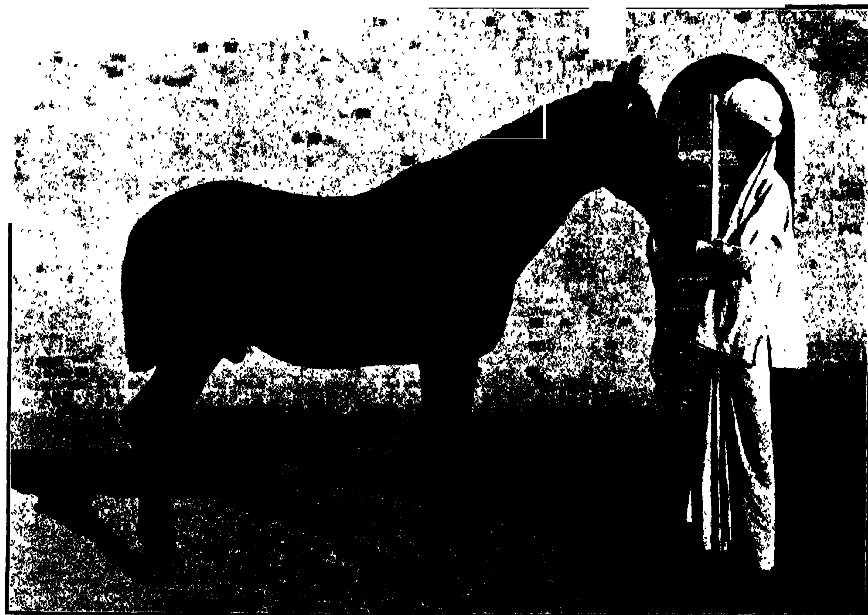
Another common complication in the stallion is due to the invasion of the lymphatic vessels of the spermatic cord by the trypanosome. In this way are produced slight, very chronic inflammations of the cord, epididymus and testicles. The result is enormous thickening of the cord, complete loss of the gland tissue of the testicle and the development in its place of an enormous amount of fibrous tissue.

In these cases there are for some time symptoms of continued irritation, the animal standing with one or other of the hind legs raised alternately. The gland is, of course, eventually destroyed and the horse useless as a stallion.

Another not unfrequent complication is due to the localization of the parasite in one or other of the joints, hock, hip, fetlock, etc. This sets up varying degrees of synovitis, in some cases



Showing synovitis of hock joint.



An apparently cured case of Dourine.



An old case of Dourine in Mare showing typical lesions of vulva.



Showing swellings on both sides of vulva and perineum.



Showing swelling of one side of vulva after Lingard.

slight and the symptoms intermittent. At other times the changes are serious, the joint distended with fluid, the animal unable to use it and ulceration of the cartilage taking place.

The parasite may invade the tissues of the eye and give rise to conjunctivitis, inflammation and ulceration of the cornea, etc.

The mucous membrane of the nose at times becomes eroded and a purulent discharge may occur in small quantity while at the same time the submaxillary lymphatic gland is enlarged and the inguinal glands suppurating. Such cases resemble glanders.

As has been said before the various symptoms do not all appear in every case. Higgins, who investigated the disease in Canada, gives the following table of symptoms (showing the frequency per cent of symptoms) in stallions and mares as he observed them :—

	Horse	Mare
Swelling of vulva	...	34
Swelling of penis	75	...
Discharge from vulva	.	20
Swollen œdematous mucous membrane, vagina .	.	70
Eversion of the meatus urinarius	65	...
Phymosis, paraphymosis	37	...
Leucodermic patches	62	34
Nervous inco-ordination, hind quarters . .	25	30
Patches	..	6
Localized œdema	75	10
Keratitis, corneal opacity	25	4

These do not correspond with what is seen in India. In all the cases seen out here there were swollen œdematous mucous membrane of vagina in mares and œdema of prepuce in the horse and only one case has been noted in which patches were not seen at some stage of the disease.

Although some horses do recover in the cases of apparent recovery the symptoms as a rule only stop developing and the animal picks up in condition when rested and well fed, but the disease still remains present in a latent state, and if the horse be again put to stud work it is very likely that it will reappear with renewed virulency. The prognosis therefore is not usually favourable and temporizing methods of suppression are not recommended. It often happens in favourable circumstances that an animal may have Dourine for several years in a latent form.

Recovery. Recovery may occur at any stage but it is more frequent in cases in which the symptoms are little developed. When it occurs the morbid phenomena diminish, the wasting of the body ceases and the animal gets into good condition. The other symptoms nearly disappear. Some of them, however, such as doughy swelling of the sheath and leucodermic patches on the skin of sheath and scrotum remain. Paralysis of the lips of the vulva with flaccidity, wrinkling and gaping of the lower part frequently remain. Continental authorities regard complete recovery as rare.

Observation of the parasite. It is not an easy matter to find the parasites in many cases. Indeed it is often so difficult that some veterinarians thought that the Dourine of Europe differed from that seen in Algiers and India. This, however, has now been found not to be the case as careful observation in favourable cases has shown that the parasite does exist and is the cause of European Dourine.

The best time to find the parasite is in the earlier stages of the disease. It exists in very few numbers in the circulation of the blood of the horse and it is practically impossible to find it there. The examination of this fluid is therefore not much good.

It is easiest to find in the blood and œdema from the œdematous swellings of the penis or blood and œdema, etc., obtained by scraping the congested and œdematous mucous membrane of the vagina. In some cases it persists for a long time in the tissues at the seat of inoculation, but it is not always easily found there at all times, as it apparently occurs in crops, although not so markedly as does the trypanosome of surra.

The next best seat is in the blood and œdema from the newly formed patches in the earlier stages of the disease.

In these it exists in varying numbers, at times being few and difficult to find, at other numerous and quite easy to find.

It is not at all easy to find in advanced cases as a rule and indeed when the patches are not forming in old cases it cannot always be seen.

It does exist in the blood of the general circulation at times, however, because if a large quantity of this, 10 c.c. for instance, be

PLATE XI.



Trypanosoma Equiperdum

injected into a susceptible animal it will usually cause the disease. But a large quantity of blood is necessary and even then it is not always successful excepting when the disease is active and symptoms are appearing.

Diagnosis. In places where the disease is known to be prevalent and where it is suspected that animals have been exposed to contagion, diagnosis in ordinary cases is a fairly easy matter when the classical symptoms are present, but in advanced cases where these have ceased, or where symptoms appear at long intervals, it is often a very difficult matter. Swellings of an œdematous nature and skin patches are diagnostic. Paralysis is very suspicious, old callous swelling of the sheath especially when associated with leucodermic spots is fairly diagnostic. Wrinkled, flaccid vulva open at lower end and showing congested membrane, especially when associated with skin leucoderma, is also diagnostic.

There are some cases, however, where symptoms are latent and nothing diagnostic is seen.

As may be readily gathered from what has already been said, there is great difficulty in diagnosing some cases of chronic and latent Dourine and owing to this fact the control and eradication of the disease in horses has always been a troublesome business. In dealing with them it is the custom to trace the disease so far as is possible to its origin and then to keep under observation all mares and stallions which directly or indirectly have been exposed to the disease. Animals which show clinical evidence of the affection are either at once destroyed or else so dealt with that they are no longer used for stud purposes.

The ideal proof is the microscopic demonstration of *trypanosoma equiperdum.* But this is generally difficult and sometimes an impossible task.

This procedure of diagnosis often requires a prolonged period of isolation and observation and can only be undertaken when horses can be kept under control. This is generally possible with good horses in India.

At the same time a very great deal of experience is necessary before one can, from the sometimes slight traces visible, diagnose

the disease. It was in view of this difficulty that I made a recommendation to the Board of Scientific Advice that the Imperial Bacteriologist be instructed to ascertain whether the complement fixation test devised by Mohler, Eichorn and Buck and adopted in America could be carried out successfully in India.

The complement fixation test is so far the only one known which is likely to be of any use for the diagnosis of occult cases of Dourine. It has been adopted in America and it is reported that in the numerous cases which have been tested the results were almost invariably definite and only on very few occasions has it been found necessary to make retests on cases which appeared typical. The reaction obtained is well marked.

Mohler, Eichorn and Buck in 1914 stated that since testing was undertaken by the method described, 8,657 samples had been examined from the Montana, Cheyenne and Standing Rock Indian Reservations in North America. Of these 1,076 gave positive reactions, which appears to be a very large proportion, but when it is remembered that the animals were kept under range conditions, without sanitary or veterinary control, and also that before the disease was recognized as Dourine, it had been diagnosed for a long period as some other affection, it will be apparent that the opportunity for spread was ideal.

With this system of diagnosis, by which even the latent cases can be determined, there is every chance of eradicating the disease.

If the test proves reliable in India all breeding animals which have been exposed to the infection, should be submitted to it.

Mode of contagion. In an ordinary way the disease is transmitted from the diseased stallion to the mare or from the diseased mare to the stallion during the act of covering. All mares which are covered by a diseased stallion are, however, not infected, but only a certain number. In an experiment it was found that of fifteen mares covered by the same diseased stallion only ten of them were infected, the remainig five escaping.

Transmission is undoubtedly favoured by abrasion of the mucous membranes of the diseased and the healthy animal. Much also depends on the presence of the trypanosomes in the œdematous

penis or vagina in considerable numbers at the time of covering. The swollen œdematous penis is readily abraided during covering; the increased size of the glans penis at this time rendering it more liable to be so.

Many mares escape when the trypanosomes are few in the diseased tissues and the healthy mucous membrane is not abraided.

The stallion is naturally a more powerful means of spreading the disease as he covers a number of mares during the season.

Stallions are readily infected by a diseased mare.

Experimentally subcutaneous inoculation of the blood and œdema containing the parasite, causes the disease and in such cases the incubation varies from seven to twenty days as the parasites are numerous or few in the material used.

The trypanosome may be easily inoculated subcutaneously into the rabbit and multiplies at the seat of inoculation often remaining localized there for a considerable time before other symptoms appear. It generally gives rise to œdematous swellings on the ear in which the parasites are easily found. It often causes loss of hair over large portions of the body, patches of dry gangrene of the skin, orchitis with abscess formation and ophthalmia.

Course and termination. The disease in India seems to differ very little from that seen in other countries. It may in some cases run a fairly rapid course terminating fatally in a few months, but as a rule the progress of the disease is slow and chronic. It appears that country-bred horses are not quite so susceptible as imported ones and that the mortality is less in India, being 40 to 50 per cent against 70 per cent in Europe.

Of four stallions which died in the Veterinary College in Paris the time taken was 11 months, 20 months, 23 months, and 26 months respectively.

Viardot, who had much experience in Algeria, concluded that weakly animals died in from four to eight months, but that it varied greatly according to the constitution of the animal attacked and to the severity of the attack. In twelve stallions the average period was 91 days but strong well-fed young animals lived from a year to three, four or even five years.

In Lingard's fatal cases three mares died in 75 days, six and seven months respectively.

We have cases on record in stallions in which the disease is still in an active state more than three years after the first symptom.

In the longer cases there are intermissions and paroxysms. The swelling of the prepuce may be the only symptom present at times and other symptoms appear from time to time.

In India many cases run a very long course, especially if animals are kept under good conditions and not allowed to cover. A great number of horses show the following course:—Typical primary swelling of prepuce of an intermittent character and urethritis followed in due course by patches on the skin, loss of condition, especially muscular wasting of the muscles of the quarter. The symptoms show intermissions at first and later on the swelling of sheath becomes more permanent, enlarging and decreasing at longer and longer intervals. The patches are more numerous at first and appear at shorter intervals, and later on in the disease become fewer and appear at longer and longer intervals until finally none may appear for months.

In favourable cases recovery may occur, but it is extremely difficult to decide whether an animal apparently cured is really so, as the disease may lie dormant for a very long time and then suddenly light up again.

Old lesions generally remain, such as enlargement of sheath and leucoderma in the horse and the open lips of the vulva with the clitoris enlarged and congested showing between them and the loose wrinkly vulva leucodermic patches in the mare.

In severe cases emaciation is most remarkable in the gluteal region. The lymphatic glands in various parts of the body enlarge and may suppurate: opacity of the cornea at times makes its appearance. The urine generally becomes thicker and darker coloured.

Weakness especially of the hind quarters often occurs, the gait becomes uncertain, and knuckling over the fetlock occurs. At a later period, the animal can no longer stand, the hind legs give way, and leave him sitting like a dog and unable to rise.

In such cases anæmia is severe, the heart beats strong and tumultuous, shaking the animal at each beat, the temperature falls, sensation is lost, and death results.

Pathology. The trypanosome gains entry into the body normally through the mucous membrane of the genital organs. It can gain entry also through a scarification of the skin artificially produced, and by subcutaneous inoculation.

It is said that it can penetrate the uninjured mucous membranes. This appears to me to be doubtful and I am inclined to think that it does not do so. Any slight abrasion will of course allow of its entering.

The most reasonable explanation of the means of infection seems to be that, if the stallion is the infecting agent, then the parasite is present in the œdematous penis at the time of covering, and gets out of the penis along with some œdematous fluid through an abrasion occurring at the time of covering, and infecting some small laceration or abrasion on the mucous membrane of the vagina, or *vice versâ.*

This explains how it is that the same stallion only manages to infect a small proportion of the mares covered by him.

It is quite possible for the disease to be spread from diseased to healthy animals by sponges, *jharans*, etc., if care be not taken, but this is not a common method of spread.

When the trypanosome has once gained entrance to the mucous membrane or to the subcutaneous tissues it multiplies there and sets up mild irritation especially of the lymph tissues and thus produces œdema. The mucous membrane of the generative organs is doubtless the most suitable position for it but the subcutaneous tissue is also favourable for its development and multiplication. It appears to have a special liking for the lymph, multiplying by preference in the lymph and not in the blood, being taken up by the lymphatics from the original seat of entry. It is generally to be found intermittently at the original seat of entry for a very long time and crops of trypanosomes continue to be produced there during most of the time the disease exists. Hence there are sometimes swellings and at others none. Hence also

when the parasites are present in the original lesion of the genital organs the animal is more likely to be infective and at other times it will be less so.

Wherever the trypanosome exists in the tissues this mild irritation results and hence arise the various lesions which are seen in the disease.

When the parasite has remained for a time at the seat of inoculation it invades the lymphatics and being arrested for a time in the lymphatic glands, sets up chronic inflammation there which causes them to become enlarged and hardened and at times to suppurate.

When the seat of entry has been in the penis then the external inguinal glands are early enlarged and indurated.

In some cases the trypanosome rapidly invades the lymphatics of the spermatic cord, epididymus, and testicle and in such cases orchitis and epididymitis result and this is of a very chronic nature and results in thickening and engorgement of the lymphatics of the cord and testicle, the formation of a large amount of fibrous tissue, atrophy of the testicle and loss of its gland structure ; a scraping made from such a testicle will show that there are no spermatozoa present.

As the disease progresses the superficial lymphatics are seen to be raised above the level of the skin at certain points.

In the mare when infected by way of the vaginal mucous membrane the initial changes are generally seen in it and consist of congestion and chronic inflammation with œdema of the tissues accompanied by a discharge of varying character. There is redness, heat and swelling and in some instances pain. The membrane is infiltrated and irritable. The clitoris is generally considerably irritated, congested, swollen and erect and the mare is, in such cases, sexually excited, and frequently passes urine.

After remaining for a certain time localized the trypanosomes gain entry into the general circulation and produce the other constitutional symptoms seen during the disease. The toxins excreted give rise to anæmia, loss of condition and cause frequent attacks of urticaria. Wherever they may become localized they set up a

chronic form of inflammation. If they gain access to the subcutaneous tissues they cause œdema and multiply there, giving rise to a plaque or patch of œdema; when they become localized in the spinal cord, paralytic symptoms result due to the slight chronic inflammation produced in the cord.

They sometimes become localized in the joints and synovial fringes giving rise to chronic synovitis and swelling of the joints, accompanied at times by ulceration of the cartilage.

In some cases the eye is attacked and we get the organisms multiplying in the tissues there and giving rise to chronic inflammation and œdema, opacity of cornea, also infiltrations in iris, choroid and retina. When the trypanosomes disappear it is common for the opacity to disappear also. When the irritation continues for a considerable period productive inflammation results.

When the trypanosomes localize and multiply in the cord, chronic inflammation results and the nervous signs shown in some cases.

Nutrition is interfered with and anæmia results from the loss of nutritive material absorbed by the parasites and from the action of the toxin.

Conception and abortion. Fleming states that mares which have conceived usually abort towards the third or fourth month of gestation. Should the full term of pregnancy be reached the foal produced is dwarfed, badly formed and either dead at birth or dies soon after.

It is generally found in India that where the disease is prevalent abortions are of common occurrence but this is not invariably the case. Healthy foals are occasionally born from mares affected with Dourine. Higgins in Canada reports that three mares in the last stage of Dourine have given birth to apparently healthy foals and three other mares found to be affected with chronic Dourine had young foals at foot.

He considers that abortion is a rare event occurring only in advanced cases where there is emaciation and loss of co-ordination of muscles of the hind quarters. The stallion is often useless from orchitis and the mare from invasion of the ovary.

Mortality. In one instance 107 mares were served by diseased stallions. Out of this number 92 were infected, 54 died and the majority of the others had not recovered their health a year afterwards.

At Tarbes out of 750 mares put to diseased stallions 107 became diseased and 52 died.

.In another stud of 150 maies covered by infected horses 58 were infected and 40 died.

In another instance out of 321 mares the loss was 160 and of 14 stallions 10 became infected and 5 died.

No records are available for India. It will be seen that in other countries the loss is variable though always serious, seldom less than 50 per cent, often more in horse kept at work, covering mares.

Many country-bred horses and mares apparently recover and a considerable number of Arabs also, when kept under good conditions.

Preventive Measures.

In Algeria where the disease is of common occurrence the following ministerial instructions are in force :—

(1) Owners of horses and asses affected with Dourine are bound to report it to the headman.

(2) The animal must be isolated pending the arrival of the veterinary surgeon.

(3) The animal declared sick shall be seen by a veterinary surgeon as soon as possible.

(4) When the symptoms seen are suspicious but not diagnostic the animal must be kept isolated under observation until diagnosis is possible. In cases where this cannot be done the horse must be seized and taken to some convenient centre where it can be isolated and inspected. Mares may be left after infibulation so as to render covering impossible.

(5) All horses attacked should be castrated or slaughtered whichever is considered best. In order to prevent owners from hiding cases they should be liberally indemnified.

(6) No indemnity should be given if cases are not declared. The owners on the contrary shall be prosecuted and fined.

(7) Veterinary Officers in Remount Depôts are invited to instruct all persons, who have anything to do with breeding operations, of the signs by which the malady can be recognized and all remount officials sent to districts where the disease exists should be thoroughly instructed in the matter.

In the stands no mare shall be presented to the stallion until a careful examination has been made. If there is any doubt then service should be refused and the mare reported to the officer in charge.

The stallions shall be carefully examined daily and in case of the slightest symptom being detected the horse should be reported and taken out of service until examined by a veterinary surgeon.

It has since been decided that in the case of a definite diagnosis the animals shall be slaughtered unless in the case of stallions the owner agrees to their emasculation. Mares are invariably slaughtered.

In India the following Act is in force, but it errs on the side of too much caution. An experienced man should be trusted to diagnose Dourine without demonstrating the parasites which is often not possible.

ACT V OF 1910.

WHEREAS it is expedient to provide for the prevention of the spread of Dourine; It is hereby enacted as follows:—

Short title and extent.

1. (1) This Act may be called the Dourine Act, 1910.

2) This section extends to the whole of British India: the rest of this Act extends only to such areas as the Local Government may, by notification in the local official Gazette, direct.

Definitions.

2. (1) In this Act, the expressions "inspector" and "veterinary practitioner" mean, respectively, the officers appointed as such under this Act, acting within the local limits for which they are so appointed.

(2) The provisions of this Act relating to entire horses shall apply also to entire asses used for mule-breeding purposes.

Registration of horses.

3. The Local Government may, by notification as aforesaid, make such orders as it thinks fit directing and regulating the registration of entire horses maintained for breeding purposes.

Appintment of inspectors and veterinary practitioners.

4. (1) The Local Government may, by notification as aforesaid, appoint any persons it thinks fit to be inspectors, and any qualified veterinary surgeons to be veterinary practitioners, under this Act, and to exercise and perform, within any area prescribed by the notification, the powers conferred and duties imposed by this Act upon such officers, respectively.

(2) Every person so appointed shall be deemed to be a public servant within the meaning of the Indian Penal Code.

Powers of inspector.

5. An inspector may—

(a) enter and search any building, field or other place for the purpose of ascertaining whether there is therein any horse which is affected with Dourine; and

(b) prohibit, by order in writing, the owner or keeper of any horse, which in his opinion is affected with Dourine, from using such horse for breeding purposes, pending examination by the veterinary practitioner.

Duties of inspectors.

6. An inspector issuing an order under section 5, clause (b), shall forthwith forward a copy of such order to the veterinary practitioner.

Inspection of horses.

7. A veterinary practitioner receiving a copy of an order forwarded under section 6 shall, as soon as possible after receipt of such copy, examine the horse mentioned therein, and may for such purpose enter any building, field or other place.

Powers of veterinary practitioner.

8. A veterinary practitioner may—

(a) cancel any order issued under section 5, clause (b); or,

(b) if on microscopical examination he finds that any horse is affected with Dourine, order—

(i) in the case of an entire horse, that it be castrated,

(ii) in the case of a mare, that it be branded in such manner as he may direct, or, with the previous sanction of the Commissioner or such other officer as the Local Government may appoint in this behalf, that it be destroyed.

Compensation for horse destroyed, etc.

9. When any horse is castrated or destroyed under any order made under section 8, the market-value of such horse immediately before it became affected with Dourine shall be ascertained; and the Local Government shall pay as compensation to the owner thereof—

(*a*) in the case of a mare which has been destroyed, or of an entire horse which has died in consequence of castration, such market-value, and,

(*b*) in the case of an entire horse which survives castration, half the amount by which such value has been diminished owing to infection with Dourine and castration.

Settlement of compensation.

10. The amount of compensation to be paid under section 9 shall be decided by a veterinary practitioner.

Committees for hearing appeals.

11. (1) The Local Government shall, by rules published in the local official Gazette, constitute a committee or committees for the hearing of appeals from decisions under section 10.

(2) Such rules shall provide that not less than one member of any committee constituted thereunder shall be a person not in the employ of Government or of a local authority.

Appeals.

12. Any owner may, within three months from the date of a decision under section 10, appeal against such decision to the committee constituted in that behalf by rules made under section 11, and the decision of such committee shall be final.

Compensation for mare branded.

13. When any mare is branded under an order made under section 8, the Local Government may pay to the owner thereof such compensation as it thinks fit.

Rules.

14. (1) The Local Government may make rules for the purpose of carrying into effect the provisions of this Act.

(2) All such rules shall be published in the local official Gazette, and, on such publication, shall have effect as if enacted in this Act.

Penalties.

15. Whoever uses or permits to be used for breeding purposes—

(a) any horse which has not been registered in accordance with the requirements of a notification under section 3, or

(b) any horse in respect of which an order under section 5, clause (b), is in force, or

(c) any mare which has been branded in pursuance of an order made under section 8, clause (b),

shall be punishable with fine which may amount in the case of a first conviction to fifty rupees, or in the case of a second or subsequent conviction to one hundred rupees.

CONCLUSIONS.

In India where horses are not in great numbers in the districts and where they are readily handled for examination as well as being under more or less constant observation the problem of dealing with the disease is an easier one than it is in places like the Indian Reservations in America where the horses run wild in mobs and can only be examined with great difficulty. There are places, Baluchistan for instance, where it is very difficult.

What is required in India is a good knowledge of all the various phases of the disease, great tact and consideration for owners, a good deal of acumen and patience.

It appears to me that the best thing to do on the discovery of Dourine in a horse or jack in a breeding district is to stop covering until an examination of all the horses, jacks and mares used for breeding has been made and those apparently free are provided with certificates to this effect.

All animals known to have visited the diseased should be most carefully examined and watched. The records will generally show these for the Horse Breeding Department and the registers for

the District Board horses. At the same time all stallions belonging to private owners should be registered and inspected.

Castration of stallions not used for breeding purposes should be encouraged.

When a general examination has been made and covering re-opened careful supervision is necessary. The early symptoms of the disease should be made known to all owners of breeding stock. A mare showing any symptom of old or recent Dourine should, I think, be destroyed and the owner compensated. This is safer than branding if it can be done without trouble. It is certainly the cheapest course in the end as it is generally impossible to say when a case which may recover is really free from danger.

It is a great hardship on the owners of mares to suspend breeding operations indefinitely as they are thus put to great loss and will sell their animals to whoever will buy them and will take them to any stallion they can get—both dangerous practices as disease is spread far afield in this way. Sales should, if practicable, be stopped for a time.

Stallions should be kept under constant supervision, and any showing the slightest œdema of yard or sheath stopped covering at once, and be examined by the veterinary officer.

The mares brought for service should be very carefully examined and any showing signs of Dourine should be noted and refused service pending examination by the veterinary officer. The more recent cases will, if the general examination has been skilfully made, be the ones usually detected; all mares which come into season again shortly after service should be viewed with suspicion when Dourine is about and they should be very carefully examined.

General rules are best made by the veterinary officer employed who should remain making regular inspections, bi-monthly if possible, until the disease is under control or stamped out. All stallions should certainly be seen twice a month. Experiments are, I understand, being made in regard to the reliability of the complement fixation test and its adaptation to India. If this works out and proves a success it will greatly facilitate diagnosis and materially help in eradicating the disease.

MR. HOWARD ON THE MATHEMATICAL TREATMENT OF AGRICULTURAL PROBLEMS: A REJOINDER.*

BY

S. M. JACOB, I.C.S.,

Deputy Commissioner, Karnal.

THE October number of the *Agricultural Journal of India* contains a paper by Mr. Howard entitled "The Influence of the Weather on the Yield of Wheat," which, though it does not mention my work, is obviously intended as a criticism of that part of it dealing with the correlation of crops and rainfall, which was read at the January 1916 meeting of the Indian Science Congress.

I do not know whether Mr. Howard has perused the work on the same lines of Hooker, Warren Smith, and Kincer, not to mention the very considerable researches on analogous lines by a great body of workers; but, as his sweeping criticism of the non-applicability of mathematical methods to plant life affects the whole of such work, it cannot be allowed to pass unchallenged.

So much for the manner of the criticism. As to the matter thereof, it is necessary to point out that Mr. Howard's criticism, though he refers to 'crop forecasts' in general, only affects that part of the problem which is concerned with the yield per unit of area. This is not what Government understands by a forecast, which must include an estimate of area as well as of yield. The different characteristics of the two parts of the whole forecast are emphasized in my Indian Science Congress paper, and I refer to the matter now only in order that persons reading Mr. Howard's

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criticism should not be misled into supposing that he deals with more than half of the problem of crop forecasts. It being understood therefore that Mr. Howard attempts only to show that mathematics cannot be applied to the problems of yield, his contentions when summed up amount to these :—

(1) That there are many factors besides rainfall, namely soil aeration, temperature, winds, humidity and so forth, which influence the yield of a crop.

(2) Assertions that mathematics are generally inapplicable for dealing with the complex processes of plant growth.

Firstly then, if by referring to factors other than rainfall which affect the growth of wheat Mr. Howard intends to suggest that I ignore the existence of these factors, it is a palpable *suggestio falsi.* I fully recognize the importance of these factors, and if my analysis dealt with rainfall only, it is simply because, in the nature of things, a partial solution must precede a complete one. Thus, I have clearly set out the nature of the problem at the beginning of my paper, when I say "the second problem, the determination of yield of each crop per acre, is much less an economic problem than the preceding one, especially in dealing with unirrigated crops which are not much manured or weeded, and is really *a joint problem of meteorology, sub-soil physics, and plant biology.* It is a statistical problem only on account of its complexity, and the more physical and biological laws that can be applied to it the smaller will be the residual effect to which it will be necessary to apply statistical methods." Again, I have referred to the desirability of the introduction of suitable corrections for other climatic factors, such as temperature, sunshine, evaporation, precipitation in the form of dew, wind and the like, and again, "they," the prediction formulæ, "would undoubtedly be improved . . . . . by incorporating all established quantitative laws as to sub-soil moisture and plant development." It is not therefore so much a question of what, in general, are the conditions which are favourable or unfavourable to plant growth as what quantitative effect must be attributed to each of these conditions in particular. Mr. Howard insists, and rightly, on the importance of the distribution of rainfall, but,

appearing to attribute to me the neglect of this point, he ignores altogether my scheme which allows for 243 alternative possible distributions of rainfall. The scheme is empiric only, and probably Mr. Howard himself, if he gave his attention to it, could suggest improved figures of weighting. Nevertheless the scheme, as it stands, brings out a correlation of 0·91 which is so high a figure that it must certainly be regarded as of considerable significance, and, therefore that the assumed effects of various distributions of rainfall are close approximations to the truth.

Again Mr. Howard points out, what indeed seems well established, that a wheat crop can be ripened by remarkably little moisture, but in connection with the question of crop forecasting this seems rather irrelevant, or, at any rate to involve some confusion of thought, as we are concerned not with what the Punjab cultivator could do, were he familiar with the best modern dry-farming practice, but with what he actually does do, and that is in the case of *barani* lands, for which my yield formula was worked out, practically nothing from the time of sowing to the time of harvesting. In forecasting we necessarily take conditions as they are and it is idle to point out that the *zamindar* could ripen his crop with much less rainfall than actually falls; the fact is that he lets the rainfall which does occur do all the work for him, and is generally to be heard asking for more. When improved agricultural methods become common it will naturally be necessary to recast the formulæ.

Next as to temperature, the figures quoted by Mr. Howard of Mr. Leake's soil temperature observations at Pemberandah are undoubtedly valuable and I am interested to learn that, in Mr. Howard's opinion, temperatures of from 22° to 24·5° centigrade are most favourable for wheat sowings. It is a question on this very point which I put to Mr. Howard at Lucknow in January last and he then said that he could not tell me the most suitable temperature within ten degrees, although he was prepared to judge by inspection whether the field was in the right condition for sowing. It is a great gain therefore to have Mr. Howard's opinion stated within two and a half degrees. It seems very desirable to have similar

observations of soil temperature made for all typical Indian soils in the Punjab as well as elsewhere. The knowledge of these temperatures, together with statement of optima conditions by an expert botanist, would pave the way to a full quantitative analysis; in fact some American investigators, notably Warren Smith, who have followed my own lines of enquiry, have already sought a suitable function which shall express the relationship of temperature and plant growth. As to soil aeration I do not know whether it is yet ready for quantitative treatment, but it must be noted that in so far as soil aeration is increased by rainfall, my rainfall distribution scheme takes implicit account of this factor.

The same conclusion applies to the temperature effect of rainfall, and to the extent that rainfall cools the soil and air, and that cooling is beneficial to the wheat crop, the effect is taken partial account of in the equations. In fact when we correlate rainfall with yield, what we really do is to correlate the effects of rainfall *qua* water, and *qua* agency for cooling and increased aeration.

Mr. Howard's statement, therefore, of the conditions which influence the growth of wheat does not in the least show that my system of weighting is in error, though it is unquestionably capable of improvement, nor does it show that the high correlation obtained is fictitious. Nor can it for a moment be urged in the face of the quotations I have given from my Indian Science Congress paper that I have ignored the existence of modifying conditions. What the relative value of each factor is must be determined not by verbal argument, but by observation, experiment, and mathematical analysis.

I come now to Mr. Howard's criticism of mathematical methods in general for dealing with the problem of plant growth. Mr. Howard says "a mathematical treatment can hardly with confidence be applied," and again "the subject from its nature is one to which mathematical treatment cannot possibly be applied."

Does Mr. Howard really mean that you cannot apply quantitative theory to quantitative fact? Does he deny that botany tends to become more and more quantitative in its method, that it necessarily links up more and more closely with chemistry and

physics, and that mathematics is capable of dealing with the questions of heat, light, capillarity, osmosis, chemical affinity and the like which form integral portions of the complete study of botany? Is Mr. Howard unaware of the mathematical developments of the Mendelian theory, which theory its non-mathematical founder and followers have considered to be applicable to the problems of plant development? For example symbolic algebra has been applied by the present writer to the Mendelian hypothesis and the conclusions reached thereby have been shown to be in conformity with the facts, within the limits of our knowledge of the latter. Thus Mendelism *has gained, not lost,* by mathematical treatment. In the same way mathematical analysis of agricultural problems cannot fail to add to, and confirm, the knowledge obtained by observations and experiment, and is the necessary complement of that knowledge.

Man, again, is a complex of protoplasmic activity, at least as highly organized as the plant, and yet numbers of the problems connected with his heredity and environment have had light thrown on them by mathematical analysis. Lastly, is Mr. Howard unaware of the differential equations of disease-infection, duration, and distribution worked out with great ability by Sir Ronald Ross and Major McKendrick? The theory has been applied by them to man, but it is no less applicable with modification to plants, and must have an important bearing on the questions of plant disease. In the face, therefore, of so much that has already been done by the application of mathematics to vital problems, which work Mr. Howard is either ignorant of or ignores, it is simply idle for him to say that the problem by its nature is one to which mathematical treatment cannot possibly be applied. Were Mr. Howard merely to extol his own methods, or limit himself to pointing out that his knowledge of agricultural condition enables him to judge from the appearance of a field of wheat what its yield is, I for one would be the last to deny that his methods are necessary, or that his judgment is sound. But when he goes further and denies to statistical methods the right to deal with statistical results, he displays a most unscientific spirit, for science has no close season or methods.

However, Mr. Howard's antipathy to the application of mathematics to the problem of crop yield is but a variety of a very old established plant, the antipathy of orthodoxy to new knowledge and new methods, and the Pusa expert's pontifical excommunication of mathematics from agricultural science reminds me that it is by the narrow margin of less than ten generations that I escape the penalty of recantation of my error and the public burning of my pamphlet.

But there is more at stake than my own interest in the matter, and though Mr. Howard's opposition to mathematical methods can affect the course of that science or the subjects on which it may be brought to bear but slightly, it has been necessary to indicate on what illusory grounds that opposition is based.

THE INFLUENCE OF THE PRESENCE OF CALCIUM CARBONATE ON THE DETERMINATION OF AVAILABLE PHOSPHORIC ACID IN SOILS BY DYER'S METHOD.*

BY

JATINDRA NATH SEN, M.A., F.C.S.,

Offg. Imperial Agricultural Chemist.

A CHEMIST is often expected to pass an opinion as to the fertility of a sample of soil as judged from its chemical composition. By the usual method of analysing a soil, namely, by extracting it with strong mineral acids, useful information is no doubt obtained as to its ultimate limitations as a soil or its possible deficiency in some essential constituents. But the analytical figures usually obtained indicate that all farm soils, although varying in richness, contain a vast amount of plant food. Even poor soils, which scarcely produce enough to pay for cultivating them, contain the nutrients required by any ordinary crop many times over. Thus it is seen that the usual chemical analysis of a soil does not indicate clearly the immediate needs of the soil for plant food.

Attempts have therefore been made to find some solvent which would be analogous in its action to the natural processes going on in soil and would only extract the soil constituents in such proportions as would be comparable to those in which the plant utilizes them. Various weak solvents have been tried including dilute

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solutions of organic acids. It has been argued that the action of these latter corresponds to that of the natural processes bringing nutriment to the plant. Hence the method suggested by Dr. Dyer has become very general. He determined the acidity of the root sap of over one hundred species or varieties of plants, representing twenty different Natural Orders, and found the average to be 0·91 per cent acid (calculated as crystallized citric acid). The recommendation was therefore made that a 1 per cent solution of citric acid should be used as the soil solvent.

The idea that the root sap has a direct solvent action on the soil particles seems, however, to be untenable. If it were true, then the yields of the crop ordinarily produced by the plants tested should be proportional to this acidity of the sap. But this is not so. Moreover it has been proved that the roots of plants do not excrete any acid other than carbon dioxide.

This method like all other kindred ones should therefore be looked upon as an empirical one and its utility should be ascertained by a comparison with actual yields in the field and with soil surveys. Judged by this standard, the 1 per cent citric acid method has been found to be very useful when applied to Rothamsted soils. The amounts of phosphoric acid and potash extracted by this method are in accord with the known history of the plots and their yields. A fairly accurate estimation of the relative productivity of these soils could therefore be made from the analytical figures. The application of the method to soils of varying character has, however, not always given good results.

There are certain inherent limitations in such processes of extracting a soil with acid solvents as the resulting solutions are quite different in their properties from the natural solution existing in ordinary farm soils.

Some of the factors which regulate the rate of solution are the fineness of the soil particles, their composition, the strength of the solvent used, etc. The finer the particles, the more readily will the solution be effected. Again, if the cementing material of some of the aggregate particles is attacked thus causing them to fall into smaller particles, the rate of solution would be quicker

inasmuch as the surface exposed to the action of the solvent is greater. This holds in the case of particles cemented together with calcium carbonate. The solvent would thus behave differently according as there are soluble encrusting materials over the soil particles or not. As to the composition of the soil particles themselves, it is well known that any plant food, *e.g.*, phosphoric acid, exists in the soil in the form of several distinct compounds of different degrees of solubility. These substances are, moreover, present in varying amounts in different samples of soil. It thus follows that the extract obtained from a soil, by the use of a fixed amount of acid from a definite weight of soil, would only represent the condition of equilibrium with respect to the distribution of phosphoric acid between the soil and the acid solution. It is thus quite improbable that any distinction of kind can be drawn between "available" and "non-available" compounds of phosphoric acid in the soil as judged by the extract. The solution would not contain the whole or even a fixed proportion of the phosphoric acid present in a definite class of compounds which might be taken to be more capable of being utilized by the plant.

Again the strength of the solvent will vary according to the nature of the soil. If it is calcareous or otherwise rich in basic substances, the acid used would be partly (or wholly if there be enough of basic substances) neutralized. This would mean a change in the extraction capacity of the acid used. The subject is further complicated by the fact that soils absorb or "fix" phosphoric acid from solutions in contact with them. The amount of fixation varies with the nature of the soil and depends on various other factors.

It must also be noted that the amount of plant food transformed during the growing season into forms of combination which can be utilized by the plants varies with the climatic and cultural conditions prevailing during that period. Considerations of such factors as the supply and movement of water and air, the incidence of sunlight, the range of temperature, the character of the microflora present, as well as the nature of the soil, are all involved.

Hence a method of extraction which gives good results under a definite set of conditions, may after all fail to yield reliable indications when applied elsewhere. This is a question which must not be lost sight of. The relative rapidity with which available plant food is renewed in tropical countries, will of course be different from that with which these processes of weathering take place in the temperate regions. The figures for analyses of soils in the latter countries would not therefore be comparable with those obtained from the soils of the former places.

The nature of the plant is also to be taken into account. Plants differ in both their capacity for absorbing food and their need of it.

For instance, it has been found that in the case of Rothamsted soils the probable limit denoting phosphatic deficiency for cereals is about 0·01 per cent of citric-acid-soluble phosphoric acid in the surface soil. It cannot however be held that this limiting figure applies to all soils, in all places and to all crops.

Considerations such as the above must be taken into account when Dyer's method is applied to the highly calcareous soils of Bihar. When examined by this method these soils are invariably found to be poor in "available" phosphoric acid. It, therefore, seems to be of interest to find out what disturbing influences, if any, are introduced when calcium carbonate is present in soils in large amounts.

A sample of soil from Kalianpur was obtained. This contained only 0·12 per cent carbon dioxide corresponding to 0·28 per cent calcium carbonate.[1] The "available" phosphoric acid, as determined by Dyer's process, was found to be 0·318 per cent. Varying amounts of pure calcium carbonate were mixed with this soil and the mixtures were examined by Dyer's method. The following table shows the results obtained.

[1] No distinction has been made between the different bases (*e.g.*, lime, magnesia) combined with the carbonic acid in the soil, and the amount of total carbonates present in the soil has, for the sake of convenience, been calculated as calcium carbonate.

TABLE I.

The effect of additions of pure calcium carbonate.

Expt. No.	Grams Kalianpur soil taken	Grams pure $CaCO_3$ added	Grams available phosphoric acid per 100 gram soil
1	100	nil	0·3182
2	95	5	0·2094
3	90	10	0·0087
4	85	15	0·0051
5	80	20	0·0012
6	75	25	0·0009
7	70	30	0·0010
8	60	40	0·0013

It is seen that the presence of calcium carbonate considerably lessens the solvent action of citric acid. Even when the amount of calcium carbonate is only 5 per cent the "available" phosphoric acid falls from 0·318 to 0·209 per cent. The reduction in the content of "available" phosphoric acid is, however, most marked when the amount of calcium carbonate rises from 5 to 10 per cent. It is intended to make further experiments on this interesting point.

In these experiments one hundred grams of soil mixture were treated with 10 grams of citric acid dissolved in one litre of water; 7·1 grams of calcium carbonate would be required to neutralize this amount of citric acid. So extracts of soils containing 10 per cent calcium carbonate and over were neutral to litmus. But the fall in the content of phosphoric acid content is maintained till the percentage of calcium carbonate reaches 20 per cent. Hence the retarding influence of calcium carbonate was not solely due to neutralization of citric acid. Phosphoric acid was actually absorbed or "fixed" from the solution by the former.

In matters of such "fixation" or of solution, much often depends on the physical condition of the material. For instance, it is well known that samples of calcium phosphate have quite different manurial effects according as this substance is used as ground rock phosphate or steamed bone flour although both of these are chemically similar.

An attempt was therefore next made to use, as the calcareous diluent for the Kalianpur soil, a sample of calcium carbonate which would be comparable in its properties to the calcium carbonate naturally present in Bihar soils. For this purpose Pusa soil containing 15·22 per cent carbon dioxide, corresponding to 34·86 per cent calcium carbonate,[1] was chosen. The amount of available phosphoric acid in this soil was 0·0014 per cent.

The following results were obtained :—

TABLE II.

The effect of adding Pusa soil.

Expt. No.	Grams Kalianpur soil taken	Grams Pusa soil added	Grams available phosphoric acid in the soil mixture	
			found	as calculated from expts. Nos. 1 and 18
1	100	0	0·3182	......
9	95	5	0·2946	0·3024
10	90	10	0·2011	0·2865
11	85	15	0·1949	0·2707
12	80	20	0·0923	0·2548
13	75	25	0·0586	0·2391
14	70	30	0·0447	0·2232
15	60	40	0·0243	0·1916
16	50	50	0·0170	0·1598
17	40	60	0·0136	0·1281
18	0	100	0·0014	......

These figures show that, as in the case of pure calcium carbonate, Pusa soil also brings about a retardation of the solution of soil phosphates by citric acid. The greatest relative retardation takes place when the amount of Pusa soil added is about 25 per cent. This corresponds to about 8 per cent calcium carbonate. It is interesting to note that the retardation produced by the addition of pure calcium carbonate (*vide ante*) is also most marked when the amount of calcium carbonate rises from 5 to 10 per cent. The action of pure calcium carbonate seems to reach a limit when the amount added goes up to 20 per cent, higher amounts causing no further diminution of the solvent action. In the case of Pusa soil, however, the retardation is continuously exerted in all the mixtures

[1] See previous foot-note.

tried. The influence of Pusa soil is much less pronounced in amount than that of pure calcium carbonate. Even if the action of equivalent quantities of calcium carbonate contained in Pusa soil is compared with that of pure calcium carbonate, the influence exerted is seen to be much less in the case of Pusa soil. It is thus apparent that the action in the latter instance is due to other factors besides the presence of calcium carbonate.

It may be noted that in the experiments of Prof. Hall and Mr. Amos where the same sample of soil was treated with successive quantities of 1 per cent citric acid, it was found that less phosphoric acid was extracted by the second than by the first extraction. But after a falling-off in the second extraction, a rise in the amount of phosphoric acid going into solution was generally observed. This rise coincided with the complete removal of calcium carbonate from the soil.

This difficulty about the determination of available plant food by Dyer's method from soils containing carbonates inasmuch as the acid is liable to be neutralized, has been felt by previous workers. Some proposed the addition of an extra amount of citric acid sufficient to neutralize the earthy carbonates. Others are against the addition of this extra amount. But it is seen that other considerations besides the neutralization of the acid come into play in this process. This method can therefore not be taken as an infallible guide to determine the limits of the fertility of a soil and of itself should not be relied upon. The problem of discovering an accurate method to determine the availability of plant foods which would be applicable to all soils, still remains to be solved.

[*Note.* It must be recognized that even in the case of highly calcareous soils the measurement of the "available" phosphoric acid gives valuable diagnostic indications of the manurial requirements of the soil. The presence of a large proportion of calcium carbonate would largely prevent the acids of the soil (carbonic and organic acids) from acting normally in their work of bringing the insoluble phosphates into a soluble condition such as is necessary to serve as plant food. Abnormally low values in such cases obtained by the citric acid method would indicate a corresponding deficiency of soluble phosphate for the plant to utilize.

As regards the soils of Bihar it must be clearly recognized that not only is the "available" phosphate with few exceptions extraordinarily low (varying from 0·00012 to 0·01 per cent) but the "total" phosphate, from which this soluble phosphate is derived is abnormally deficient. The analyses made by Rawson in 1899 of a number of indigo soils, show that the "total"

phosphate, especially in Champaran, was less than 0·1 per cent, whilst a comparison of these analyses with those made by Dr. Leather in 1907, show that the phosphate supply has been steadily diminishing since. The small proportion of "total" phosphate is indeed responsible for the abnormally low values for "available" phosphate found in these soils. The high proportion of calcium carbonate increases the difficulty of obtaining sufficient soluble phosphate from the small phosphate reserves of the soil.

Superphosphate manuring, indeed, gives the most striking results in the case of soils in which the high proportion of calcium carbonate diminishes the rate of formation of "available" phosphate in the soil. This is clearly shown by the results as yet unpublished, obtained on the experimental plots at Pusa during the past ten years, where manuring with superphosphate alone gives the maximum results—the crops being more than doubled. Superphosphate alone gives practically the same results as farmyard manure containing the same weight of phosphoric acid. The addition of other artificial manure (sulphate of ammonia or sulphate of potash) to the superphosphate does not increase the crops beyond the point reached with superphosphate alone. Green-manuring on the Pusa plots gave very little increase as compared with the unmanured plot, but by adding superphosphate as well, the yield was frequently doubled or even trebled.

So long ago as 1901, according to the report of the Indigo Improvement Syndicate written by Bernard Coventry, the experiments made at Dalsing-sarai showed that the response of the soil "to the action of superphosphate is marvellous." In 1899 with mustard, for instance, there was an increase of 800 per cent. In the few cases where superphosphate has been applied in Bihar on the large scale, for example, at Dalsing-sarai, Dooriah, Dholi, heavy dressings have amply repaid the cost; in many cases the crops have been doubled and the profit was greatest where superphosphate was most heavily applied (5 cwt. to the acre). Other manures, such as nitrate of soda, gave no increase of crop; the limiting factor was deficiency of phosphate.

In all such cases the *practical* results obtained by superphosphate manuring have supported the diagnosis of phosphate deficiency revealed by determination of the "available" phosphate by the ordinary method. Superphosphate manuring in fact is likely to give its best results in soils which are so rich in calcium carbonate that the ordinary processes by which phosphate is rendered available are impeded. Experiments made by the writer at Rothamsted showed that the soluble phosphoric acid of superphosphates does not attack calcium carbonate, even when the two are boiled together. On this account the whole of the phosphoric value of the superphosphate can be utilized by the plant even in presence of large quantities of carbonate, so that its use gives particularly striking results in manurial practice.—W. A. D.]

MAJOR JOHN WALTER LEATHER, V.D., F.I.C.

BY

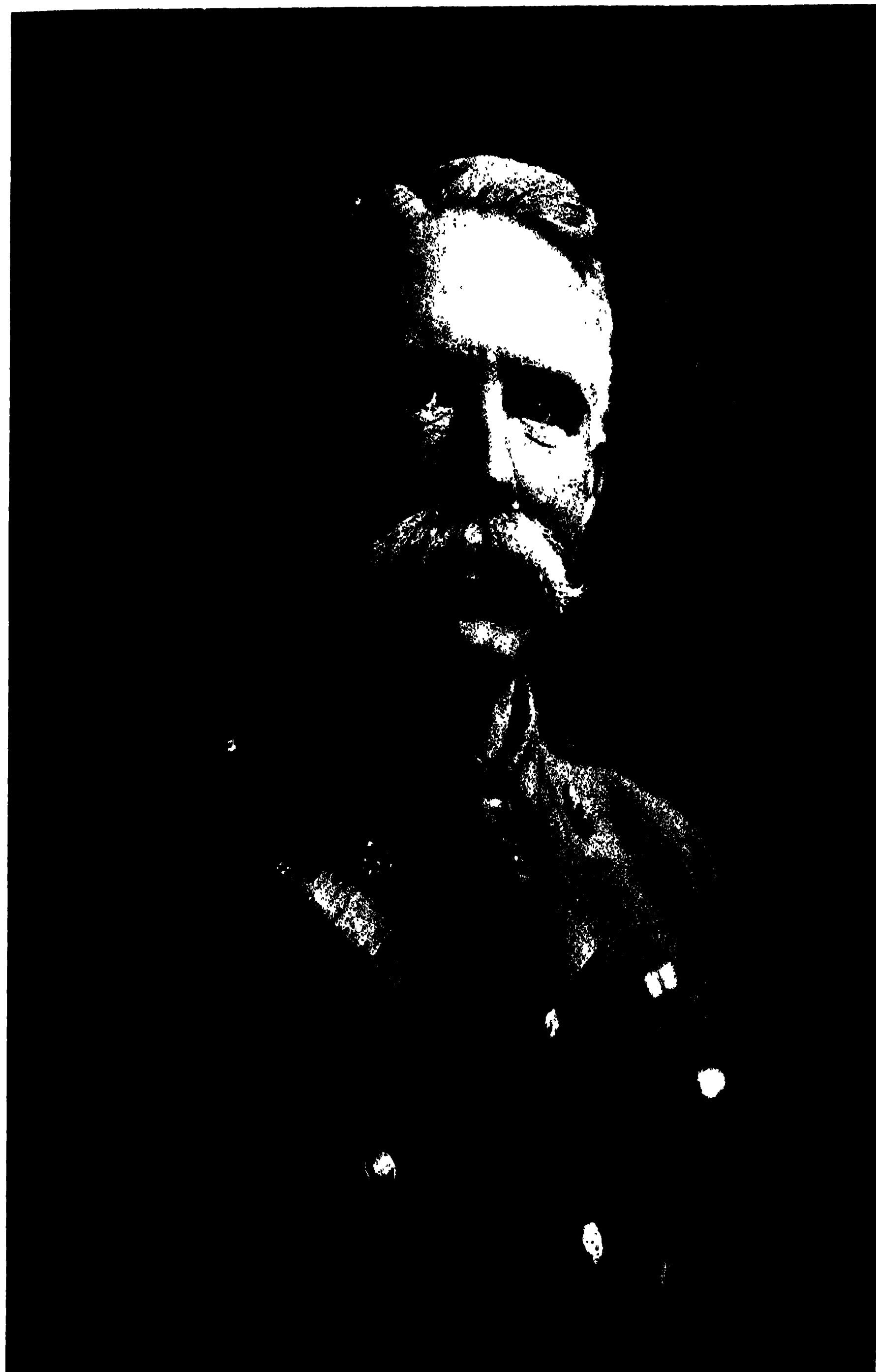
J. MACKENNA, M.A., I.C.S.,

Agricultural Adviser to the Government of India.

MAJOR LEATHER, Imperial Agricultural Chemist, retired on the 12th August, 1916, after 25 years' service with the Government of India.

John Walter Leather, the eldest son of John Knowles Leather, was born at Rainhill in Lancashire on December 26th, 1860, and was educated at Hayton College.

After leaving school he entered his father's chemical factory at St. Helens, but soon left the factory to undertake a systematic course of chemical study. At that time the facilities for such study in Great Britain were very different from what they are to-day, whilst on the other hand the Universities of Germany had attained a high reputation. Hofmann, Kekulé, Bunsen were still active whilst the work of Van't Hoff and Ostwald was coming into prominence. Leather selected Kekulé's University—Bonn on the Rhine—where he spent the three years 1883-86 and obtained the degree of Ph.D. This he renounced at the outbreak of war. On leaving the University, the appointment of senior assistant to Dr. John Augustus Voelcker, the consulting chemist to the Royal Agricultural Society of England, was offered to him and accepted, and this post he held for six years. About 1890 the County Councils commenced their efforts to aid British agriculture by the institution of agricultural schools and in 1891 Leather was appointed Professor of Chemistry at the Harris Institute, Preston. In the following year the Secretary of State for India decided to



MAJOR JOHN WALTER LEATHER, V.D., F.I.C.

appoint a chemist and an assistant chemist to the Revenue and Agricultural Department of the Government of India. Leather was selected for the former and S. H. Collins for the latter appointment.

The appointment of " Agricultural Chemist to the Government of India " was changed to that of " Imperial Agricultural Chemist " in 1906, when concurrently with the considerable expansion of the Indian Agricultural Department and the creation of an " Indian Agricultural Service " the titles of the appointments were systematized. In this appointment the remainder of his service was passed.

Leather became a Fellow of the Institute of Chemistry of Great Britain and Ireland in 1890, and was elected to the Chemical Society (London), the Society of Chemical Industry, the Society of Public Analysts, the Royal Agricultural Society of England, and the American Chemical Society.

In 1915 he obtained the permission of the Government of India to go home in order to seek war work. He had served 23 years in the Indian Volunteer Force (Dehra Dun Mounted Rifles and United Provinces Horse) and had been awarded the Volunteer Officers' Decoration. Shortly after his arrival in England he was appointed a Major in the 3rd Garrison Battalion, Cheshire Regiment, in which regiment he is now serving.

During the course of his service with the Government of India, Leather did much valuable chemical investigation. He was particularly successful in the training of Indian assistants, by a large body of whom he is held in affectionate remembrance. A strong disciplinarian, he insisted on good work but never withheld praise and commendation when it was due. Both officially and socially he was held in high esteem and the departure of Major and Mrs. Leather has left a gap in the society of Pusa which it will be difficult to fill. The best wishes of the Department follow them in their retirement from civil life in India and in the new career which Major Leather has adopted.

NOTE ON AN OUTBREAK OF CONTAGIOUS PNEUMONIA IN DONKEYS.*

BY

R. BRANFORD, M.R.C.V.S., I.C.V.D.,

Superintendent, Government Cattle Farm, Hissar.

An outbreak of this disease occurred among the young stock donkey jacks at the Government Cattle Farm, Hissar, on July 20th, 1916.

For ten months in the year these animals run out in extensive paddocks, only coming up at night into open thorn kraals. Shade temperature by day during the hot weather reaches 120° F. and during winter at night goes below the freezing point.

Young stock mules separated into fillies and geldings live in adjacent paddocks. It is customary in the rains, or perhaps here it would be more accurate to say in the months which tradition holds to be rainy, to move these animals out of the paddocks for about two months, to give the grass, if it does chance to rain, a chance of coming up, and to rest the paddocks.

They were moved this year on July 18th to lines occupied at night during the cold weather by cattle; big open yards, each several acres in extent, and each provided with lean-to, thatched shelters.

The animals were divided into four lots, two of mules and two of jacks: the mules according to sex, and the jacks according to size, into big and little.

* Received for publication on 1st October, 1916.

The animals were taken out of their lines twice daily to water, from a trough filled from a well. The trough was capable of being emptied, cleaned and disinfected.

On the 20th July, 1916, two of the small donkey colts were reported to be down with pneumonia.

I was not able to see these animals till the evening. Both were then very marked cases of pneumonia, the temperatures of both were between 106° and 107° F., the breathing of both was very markedly abdominal. Both showed signs of exhaustion, standing in a listless way, with their ears hanging half down, and penis partly protruding. One No. 295 was feeding. The other No. 301 was off feed. Their visible mucous membranes were injected, but were not icturic.

I was at first undecided whether to treat the disease as contagious or not, and on the whole inclined to think it non-contagious. Sporadic pneumonia is not uncommon here, the weather was treacherous, very hot and stuffy generally, with intervals of chilly winds and showers of rain. The animals in the course of moving across the open from the paddocks usually gallop about a good deal and get hot. I thought a chill might be mainly responsible for the cases. Meanwhile they were isolated. During the 21st no fresh cases were noticed. The temperatures of both affected animals on the morning of the 21st were approximately 105° F.

No. 301 was much worse, he was completely off feed, and terribly weak and exhausted, alternately lying down and getting up. His thorax was punctured with an ordinary trocar and canula, but little or no fluid came away, and no relief was obtained by the colt, which died during the afternoon. He had been a strong well-grown colt, and was about 15 months old.

The *post-mortem* examination revealed extensive hepatization of both lungs, only a small portion of the posterior lobe of the right lung was unaffected.

There was no pleurisy.

The pericardium was inflamed. Pus of about the consistency and colour of clotted cream could be squeezed from the bronchioles from any part of the affected lung tissue.

Smears made from the pus, stained with methyline blue, showed on microscopic examination masses of micrococci, apparently in pure culture; in parts of the field where they could be clearly seen, the cocci were mostly grouped in the form of diplococci.

On the 22nd, the temperature of colt No. 295 was still 105° F., dyspnœa was still marked, but his appetite had improved. At the inspection of the healthy colts during their morning feed, one colt No. 276 was noticed with marked abdominal breathing. He was feeding ravenously. His temperature was taken and was found to be 107° F.

It was at once decided to treat the disease as contagious, and a hospital was extemporized in one of the adjacent cattle lines, of which there were several still empty.

The sick colts Nos. 276 and 295 were moved to this hospital. The young stock mules were all moved to fresh lines about two miles away. This was done, as a previous outbreak of contagious pneumonia in young stock donkeys had occurred on the Farm in 1909 (before my connection with it), which had practically confined itself to donkeys, although both young stock mules and pony mares had been in contact. I hoped that if again in this case the susceptibility of mules should be slight, they might escape altogether if moved.

From the morning of the 23rd, the temperatures of all the donkey colts present were taken twice daily. On the 23rd, nine colts had temperatures over 103° F. but all were feeding well, and none showed any sign of any difficulty in breathing.

Another empty line was detailed for suspicious cases; animals showing slight elevation of temperature and no other symptom were sent there and carefully watched.

Animals, the temperatures of which remained in the neighbourhood of 104° F. for 24 hours, were taken to hospital. Separate arrangements for watering were made for the animals in hospital and in the line for suspicious cases. From the 23rd of July till the middle of August, fresh cases were of almost daily occurrence, and one or two cases kept on cropping up at intervals of two or three days till the end of August. Treatment consisted of cold enemas while the

temperature was high, electuaries containing quinine, application of mustard to the sides of the chest, also to the throat in cases showing any signs of laryngitis, inhalations of eucalyptus, and in some cases salines in the drinking water. Alcohol in the form of rum was given in doses of 4 oz. to one or two animals which showed signs of great exhaustion, but except for that no animals were drenched.

The total number of jacks present at the beginning of the outbreak was 77, of which 47 big ones (mostly 1½ to 3½ years old) were in one yard, and 30 little ones (mostly 6 months to 1½ years old) were in another.

Of the 47, eleven animals showed definite symptoms of the disease and were treated in the sick lines.

Of the 30, twenty-one were definitely attacked. Only one animal died, No. 301, the *post-mortem* of which is described above. At the time of the death I was not certain that I was dealing with contagious pneumonia, or probably I should have made more careful notes of the *post-mortem*.

A considerable number of animals became seriously ill and breathing was generally very noticeably affected, and markedly abdominal. Cases seriously affected all lost condition very noticeably.

In serious cases the attack generally lasted for at least 7 days. Relapses after apparent recoveries occurred in several cases ; the temperature chart of colt No. 321 is typical of this. In no case, except No. 301 which died, was any animal ever completely off his feed. The majority of cases fed well all through the attack. In no case, after daily records of all temperatures were taken, did any difficulty occur in breathing till some days after the animal had shown an elevation of temperature.

No doubt the outbreak was of mild virulence, but I am inclined to attribute a portion of the credit for the absence of casualties to the early use of the thermometer and consequent early treatment.

The chief point of interest in this outbreak as well as in the outbreak of 1909, was that, although the disease appeared to be

identical with what text-books describe as "Equine Contagious Pneumonia," or at any rate there was a remarkable similarity as regards both the symptoms and the course of the disease, probably also as regards the causal organism, yet horses appeared to be immune or at least to possess a very high degree of immunity as compared with donkeys.

During the course of the 1909 outbreak as far as I can gather from the Farm Assistant Veterinary Staff, present then, about 97 young stock donkeys of both sexes and all ages from birth up to 3 years old were in contact throughout. Eighty-eight donkey mares, 37 pony mares, some with male foals, and 107 mules of all ages from 6 months to 4 years, were in adjacent lines for part or whole of the time.

The majority of the young stock donkeys appear to have been affected and 14 died. Most of the deaths were among animals about 1 year old or younger. Some deaths occurred among unweaned foals.

One death from pneumonia occurred in an unweaned mule foal, but doubts appear to have been felt as to whether this was a case of contagious pneumonia. No cases at all occurred amongst the pony mares.

In the outbreak now described, two pony fillies aged between 2 and 3 years were running with the big donkey colts at the time the outbreak occurred. They remained with the donkeys throughout the duration of the outbreak, but never showed the slightest deviation from a condition of perfect health.

On the 24th of July, I sent a valueless mule, with big bog spavins, aged about 12 months, to the sick lines. He remained there till the close of the outbreak but never showed any symptoms of the disease.

Later I also sent a mule foal about 2 months old, which had lost its mother, and was being hand-fed, into contact with the disease, where it remained over a month. The foal never showed any signs of the disease, although it was probably at about the most susceptible age, and was also a bit run down and in poor condition owing to the loss of its mother.

One would have expected the immunity of mules to be about half as strong as that of horses ; yet those two mules must have possessed a very high degree of immunity, as not only were they running in the same yard with animals in all stages of the disease, but they were also twice daily feeding from the same trough, and rubbing their noses against the noses of the diseased donkeys, many of which had a nasal discharge.

As noticed above, age appeared to have considerable influence on the disease.

For example :—

Out of 11 colts present under 1 year old, 11 were attacked by the disease or 100 per cent.

Out of 29 colts between 1 and 2 years old, 11 were attacked by the disease, or approximately 38 per cent.

Out of 18 colts between 3 and 4 years old, 6 were attacked, or approximately 33 per cent.

Out of 19 colts over 3 years old, 4 were attacked or approximately 20 per cent.

The temperature charts of donkey colts Nos. 295, 276, 321, and 266 are illustrated, as they are typical of the various forms taken by the disease.

Nos. 295 and 276 were both severe cases. Probably both had high temperatures some days before they were noticed to be ill. Both fed well throughout their attacks, but both lost condition very noticeably.

Colt No. 266 was considerably older, and was in extra good condition. He overcame the disease much more rapidly ; symptoms of dyspnœa were noticeable on the 26th, but were never very marked.

Colt No. 321, only 6 months old, was much more severely attacked. His temperature was just under 105° F. on the 23rd, and for 10 days remained abnormal with a downward tendency, but on the 10th day rose to nearly 106° F. and by the 11th he had developed all the symptoms of the disease. After 9 days he appeared to be well on road to recovery, and then unaccountably relapsed. He eventually made a good recovery.

Selected Articles.

CAPTURING WILD CATTLE IN THE CENTRAL PROVINCES.*

BY

D. CLOUSTON, M.A., B.Sc.,

Deputy Director of Agriculture, Southern and Western Circles, C. P.

THE Central Provinces and Berar are among the most jungly parts of our Great Eastern Empire. To the *shikkar*-loving Englishman, a post there is worth many tiger skins, not to speak of the exciting sport to be had in the bagging of their game, for the forest area is so vast that civilization has not yet driven these denizens of the jungle from their haunts. Nor does the tiger hold undisputed sway in these wilds: panthers, wild buffaloes, bison and bears compete with him for territory, and wild cattle claim as much as they dare. Of these last, not man-eaters it is true, but fierce enough to afford much fun, I propose to write of an exciting experience I had in capturing some particularly fine specimens. They are known as wild cattle now and, as my tale will show, the name is well deserved: but the type of animal shows that some remote ancestors of the existing herds must have been domesticated. The supposition is that, daring and untractable spirits have, in times past, strayed beyond the confines of straggling villages and, not wishing or not knowing how to return, have lived and bred in the wilds. It is customary in India among religious devotees in times of stress and of rejoicing to dedicate cows to their gods. The animal, whose good fortune it is to be considered worthy of such distinction, is permitted to roam at large in the village and a theory

* This article has already appeared in the "Field."

is held that probably these sacred animals formed the nuclei of some of the existing herds of wild cattle, but this is only speculation. In any case, the forest is now their home by right of adoption, and how to check their ravages has exercised the minds of Government officials in recent years; for, in several districts, these cattle have multiplied so as to become a pest to the village cultivator, whose crops they damage at night. The original trait, which led them away from the shelter of their stalls, has developed abnormally, and they now travel long distances by night in search of food and drink. In the hot season, these arid plains of India afford but few "cool, shady rills," and these cattle, like other inhabitants of the jungle, under the protecting veil of night, leave their haunts and wander thus abroad until they find a pool. This quest usually leads them into the neighbourhood of a village, and the villagers are the sufferers: standing crops are trampled down, and fodder stored in stacks in the villages even is raided at times.

A herd of about seventy of these cattle had long frequented a *babul* jungle near Khamgaon in Berar. In their nightly raids on the crops of the neighbourhood, they had done much damage, and the villagers were sorely distressed at seeing their substance depleted year after year. They appealed to Government for assistance: Government in turn issued an order to the Department of Agriculture to see that these cattle were either captured or shot. To shoot them would have been an easy task, but it seemed a pity to take the lives of so many fine animals. It was, therefore, decided to make a bold effort to capture them alive, and, if possible, to tame them for farm work or breeding purposes. With this end in view, a *kheddah* was constructed in that part of the forest most frequented by the herd during the day. This *kheddah* consisted of a circular area of nearly three acres, enclosed by a strong eight-strand barbed wire-fence, supported on posts three feet apart. Each post was strengthened by the addition of a strong stay: the fence was still further strengthened from the inside by a thick paling of thorny branches, reaching to a height of seven feet. It was found, however, that the charge of these wild cattle *en masse* was something terrific, and that this formidable barricade was

only a trifling obstacle to them. As the whole herd of about seventy had escaped after being enclosed, it was deemed necessary to dig a trench round the inside of the fence which would prevent them, when inside, from rushing the wall of thorns and wire fencing. Shortly after completing this second line of defence, four bulls, which had been driven out of the larger herd, were beguiled into the *kheddah* by trails of tempting *karbi* (*juar* straw), cotton seed and salt put down outside the gate and leading up to a small stack of *karbi*, which had been placed in the centre of the *kheddah*. One of these bulls was the best of his kind which I have seen in India. All four were of a fine majestic bearing: their alertness and great strength made their capture all the more difficult. Having engaged the services of local men with strong nets, we entered the *kheddah* to begin the sport. Our first appearance was met by a wild protest on the part of the bulls, which, by a sudden charge, made us retreat pell-mell by the gateways or into trees. I had taken the precaution to have two ladders placed against the gate, so that we could, when pursued, escape by that means. On one occasion, a rung of one of the ladders broke under my weight, and a bull was close on my heels before I could get out of his reach. The first day's attempt to entrap them in nets proved futile. This method was full of risks too, for the bulls were oftener pursuing than being pursued by our men, and several men had narrow escapes of being gored before they could get up a tree or escape by a ladder.

On the second day, we decided to lasso them if possible, by using an ordinary running noose hung on the end of a long thin bamboo. The men who manipulated these entered the *kheddah* in strong covered carts each drawn by a pair of bullocks. The bulls seemed to regard the cart as being a very formidable object, and at a distance of twelve or fifteen yards shook their heads at it, but refrained from charging. Protected by the carts, the men aimed at throwing the lasso over their heads. After several attempts, we succeeded in lassoing the largest of the four in this way. His rage was unbounded when he felt the rope tighten round his throat; for, with the other end securely fastened to a tree, there was not much chance of escape. The great leviathan charged round and

round, rearing at times like a horse and bellowing loudly in his fury. It seemed at first as though the tree, visibly swaying, must give way before his great strength After some time a second lasso was thrown successfully, and the rope firmly fixed to another tree. Between these two trees, he rushed backwards and forwards in his fury, charging at every living thing that came near. Though he made a splendid fight for it, escape was impossible, and at last he rushed madly into one of the nets and fell. In a very few minutes our men nimbly scrambled down from the trees and carts in which they had taken safety, and completed the capture of this fine looking denizen of the jungle. His legs were securely tied, and in the last scene of the act a strong string was drawn through his nose, for, in anticipation of capture, the classic *hiran's* (antelope's) horn and string had been kept ready. He was at last thoroughly under our control and was securely tied to the nearest tree both by the nose string and by ropes passing round his neck. There he lay at our mercy awaiting the time when he would be taken to the Government Farm near by, where he was to be trained to the yoke.

The second largest bull of the four proved the pluckiest of the lot. At the time of throwing the lasso, our men sometimes ventured too far from the carts, and narrowly escaped injury when they were charged by the bulls. When this particular animal was lassoed, the game became still more dangerous, as he became absolutely infuriated and rushed at every living thing that came within his reach. He caught and gored one man who ventured too far from his cart, and would, no doubt, have killed him outright, had he not been enticed away from his helpless victim by the shouts of other men in a cart near by. After a prolonged and dangerous struggle, he was lassoed a second time, and then followed another most exciting incident. While the new rope was being tied to a tree about sixty yards distant from that to which the first had been made fast, the bull being at this time about midway between the two, the bull, in the twinkling of an eye, charged the man who was making the rope fast, broke the first rope, and tossed his victim, a Mohammedan butcher, wearing a red *pagri* (headcloth), about twenty feet through

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the air. He next charged a cart which he failed to overturn, and then made a savage attack on one of the cartman's bullocks, goring it from under the yoke, and pursuing it for some distance. By this time we had all made our escape—up trees or by the ladders. After an hour's hard work, he was at last brought to his knees and securely tied. The remaining two were also accounted for before the day was done. One of these afforded considerable sport, as he was caught by the hind leg while running over the noose, which had been meant for his head, but which had fallen short of the mark. He bellowed wildly, stretched himself like a trapped rabbit, and pawed the earth in his wrath.



A method of capturing wild animals.

All four were at last tied to trees, but there was still a formidable task before us, for the bulls had to be brought to the nearest Government Farm—some forty miles distant, where they were to be

tamed and, if possible, trained. The method of transfer was to tie each bull between a pair of village buffaloes. The bull which, at the time of his capture, had injured two of our men so badly, displayed his savage temper once more, by making an attack on one of the buffaloes, which he gored so badly that it succumbed to its injuries. This same bull has since been successfully tamed and now labours under the yoke and treads out the corn on the Government Farm. He is still somewhat surly in temper, more alert and quicker in his movements than his fellows, which have never known a life of freedom in the jungle, but he is, nevertheless, a useful draught animal.

Over thirty animals were captured last hot weather in a *kheddah* of this kind, but we do not recommend it as the most suitable. The area of about three acres inside the *kheddah* was much too large and great difficulty was experienced in approaching the enclosed cattle sufficiently near to 'asso them. Moreover, when once enclosed, they become dangerous, and a man can only approach them in safety by taking shelter in a heavy cart as already described. A more successful method tried was to construct a very small *kheddah* forty feet square, of strong, wooden posts three feet apart and seven feet high, with cross pieces one foot apart. To give this fence additional strength a stay is put in behind each post. The cattle are allured inside as described in the case of the previous method, and the gate is then quietly closed by the watchmen in charge. They are then lassoed one by one by men who have taken up their position in trees overhead. Fifteen were captured in this way recently without much danger or trouble. The text-figure shows how this was accomplished. This method is easily the cheaper and more expeditious and will be adopted in future as the standard method of capturing other wild herds.

THE IMPROVEMENT OF THE RICE CROP IN BENGAL BY PURE LINE SELECTION.

(A short account of Mr. G. P. Hector's work on Rice, read by Mr. R. S. Finlow in charge of the office of the Economic Botanist, Bengal, before the Provincial Agricultural Association, on 5th July, 1916.)

WORK on rice was commenced by Mr. G. P. Hector, Economic Botanist, in 1910 when 180 samples of seed, representing reputed varieties in different parts of Bengal, were sown. Typical single plants were selected from these plots and the seed was sown in 1911, when there were nearly 1,000 pure lines. Each of these plots was carefully examined and the produce was afterwards weighed. Single plants were again selected from the best yielding strains, and these were sown and their respective yields and characters again compared in 1912. In 1913 the six highest yielding varieties were grown on a comparatively large scale when careful weighments were again made. As the variety *Indrasail* had come out best in nearly all these tests, samples of its seed were sent for trial in 1914 to Government farms at Rajshahi and Chinsura and trials were also made by District Agricultural Officers on rice fields in Mymensingh and Rangpur. It was also tried on cultivators' fields near the farm. Good reports of *Indrasail* were in every case received.

In 1915 demonstrations were made with *Indrasail* in the Dacca and Mymensingh districts, and it was also sent for trial to Noakhali, Karimganj, Ranchi, and Barisal. In practically all these tests *Indrasail* has been very markedly successful; for the average margin of yield, by which it is better than local varieties, seems to be nearer ten than five maunds per acre. It is only natural that a considerable demand for so good a variety should arise,

and in the present season about seven hundred maunds, sufficient to sow from 1,000 to 1,500 acres, have been disposed of on the understanding that the option of buying back the crop lies with the Department. This scheme will, if necessary, provide us with at least 5,000 maunds of seed for distribution next year.

With paddy as with jute, the work of examining new varieties is still going, the object being the same, *viz.*, to find better yielders if there are any. To this end 1,000 new varieties were imported in 1914 and the testing of them is still in progress. It should also be mentioned that the best varieties have been obtained from several other provinces of India, including Burma, Madras, and Assam ; these will be compared with the best local varieties. Only those who are familiar with such work can realize the amount of labour it involves ; but results have, as we see, already been obtained : we hope to go further still, but even if this were to prove impossible a great achievement will have been made. If the yield of the 20,000,000 acres under rice in Bengal could be increased even by five maunds per acre, the Bengal ryot would benefit, assuming the grain to be worth Rs. 2-8 per maund, at the rate of 25 crore rupees (say, £13,000,000) per annum.

On the more purely scientific side results have also been obtained which are not only of very great interest but which may also prove to be capable of valuable application in practice. Accounts of these experiments are being published as a Memoir by Mr. Hector.[1]

During recent years a great deal of damage has been caused in low-lying tracts in East Bengal by a disease of deep-water paddy variously known as *Ufra, Dak*, etc. The ravages of the pest are very serious and the loss done by total destruction, or diminution of the yield, of crops of deep-water rice, in one portion of the Dacca District alone, is estimated at over two lakhs of rupees per annum.

The Agricultural Department commenced to investigate the disease several years ago, and Dr. Butler discovered that it is due to a nematode (eelworm). Since then, in collaboration with

[1] *See* "Observations on the Inheritance of Anthocyan Pigment in Paddy Varieties." *Mem Dept. Agr. Ind. Bot. Ser.*, vol. VIII, no. 2.

Dr. Butler, experiments have been made by the Bengal Government Economic Botanist at different centres to try and discover by what means the pest can be destroyed, or brought under control. The experiments include investigation of the effect of—

(*a*) burning stubble,

(*b*) thorough cultivation of the land,

(*c*) sowing of sound as opposed to diseased seed,

(*d*) discovering varieties which are immune, and

(*e*) rotation of crops.

Last year Government made a special grant of Rs. 4,000 which has been spent by the Collectors of Dacca, Noakhali, and Tippera on remedial schemes recommended by the Agricultural Department. It is early yet to say whether the measures proposed will be entirely successful, but there is good reason to believe that their combined effect will at least result in a reduction of the disease.

THE IMPROVEMENT OF THE JUTE CROP BY PURE LINE SELECTION.

(Paper read by Mr. R. S. Finlow, B. Sc., Fibre Expert to the Government of Bengal, before the Bengal Provincial Agricultural Association on 5th July, 1916.)

THE demand for an investigation into the improvement of the yield and, if possible, also the quality of the jute fibre dates back at least as far as 1872, in which year a Commission was appointed " to investigate the cultivation of, and trade in, jute in Bengal." A voluminous report was issued in due course by Hem Chandra Kerr. About this time the Bengal ryot was beginning to thoroughly realize the profitable nature of jute cultivation and, as the Crimean War had secured a regular market in Europe for the fibre, the cultivation of the crop was increasing very rapidly. Nevertheless the total area under jute in the old Bengal Presidency in 1874 was only 900,000 as against 3,000,000 acres to-day; but even at that early date fears were expressed that the large increase in jute cultivation which had taken place in some districts would entrench on the production of the food-grains. The report in question also deals with deterioration and confirms the existence of fraudulent watering of the fibres. These points were all brought up for discussion seventeen years later (in 1901), when the Calcutta Baled Jute Association approached Government with the request that the Agricultural Department might take up an investigation with the object of improving the cultivation and yield of jute. The request was acceded to and a Sub-Committee of the Board of Scientific Advice was appointed consisting of Mr. Mollison, Inspector-General of Agriculture; Lieutenant-Colonel (now Sir) David Prain, I.M.S., Director of the Botanical Survey; and Mr. I. H. Burkill, acting for Dr. (now Sir George) Watt. The latter had already commenced

work on jute over a year previously. During the year 1902-03 the practice of fraudulent watering of jute appears to have increased considerably, and the outcry regarding deterioration was renewed, accompanied by an insistent demand from the jute trade in Calcutta for penal legislation against the watering of the fibre.

The writer was appointed as Government Fibre Expert in 1904, although it was not until 1907 that he was free to devote the whole of his time to fibres. The first investigation was to decide on the normal moisture content of the jute fibre, and later to examine a considerable number of watered samples in order to gain some idea of the extent to which adulteration was practised. As a result of this work Government finally decided that the real cause of the evil was a discrepancy between supply and demand, and that the remedy would be to increase the quantity of jute produced partly by extending the area devoted to it and to similar fibres, and partly by improving the cultivation of jute both as regards the obtaining of better seed and the use of better agricultural methods. These considerations have determined the lines on which all subsequent work has been carried out.

In 1904 the Sub-Committee of the Board of Scientific Advice issued a report in which certain conclusions are detailed regarding the characteristics of the two species (*C. olitorius* and *C. capsularis*) and of the races of each of these which are in common cultivation in Bengal. The Sub-Committee reported emphatically against the idea of degeneration in either species, saying "the best now, as then (a century ago), if cultivated liberally, yield excellent crops, and the fibre, if properly extracted, is also excellent." At the same time the Committee pointed out that some districts may not be cultivating the most suitable kinds, and stated that "it is necessary first to discover the most suitable kinds, in some instances it may be advisable to attempt, by selection or otherwise, to evolve new kinds more suitable for the purpose than any known kind." These quotations describe clearly the lines on which the work on jute was commenced.

In 1906 the writer, in collaboration with Mr. I. H. Burkill, commenced an elaborate survey of the races of jute in Bengal

both by examination of crops in the field and by the study of plots grown from seed obtained from all parts of the jute-producing tracts. The result of this enquiry, a preliminary account of which was published in the *Agricultural Ledger*, No. 6 of 1907, showed the existence of very wide and important cultural differences between respective races of both *C. capsularis* and *C. olitorius*. It was found that some races have a considerably taller stature and therefore—other things being equal—a corresponding greater yielding power than others. A suitable basis for pure line selection as regards yielding power was thus found, and work on those lines has been continued in the interval. At the same time, with a view to improvement in the quality of fibre, a careful chemical and microscopic examination of the respective fibres of different races of jute was made another basis for pure line culture. So far no single plant has been found which combines in the highest degree all the most desirable qualities which are possible, *viz.*—

(*a*) high yielding power ;

(*b*) maximum strength and durability of fibre.

Some, however, approximate to this criterion, and it is hoped ultimately to obtain what we require by hybridization. In the meantime we have the seed of pure lines which are very heavy, if not the heaviest, yielders of fibre of excellent quality ; and of these a race called Kakya-Bombai has hitherto proved the best. This pure line has been multiplied, and in the present season roughly 150 maunds of seed was sold—sufficient to sow 1,500 acres. Next year it is expected the demand will be greater, and arrangements have been made to produce about 350 maunds of seed for sale : a special grant of money has been made by Government for this purpose. The demand for the seed has been created through demonstrations in one form or another ; for instance, in the season 1915 the average yield over more than 3 acres of plots on the poor soil of the Dacca Farm was 25 maunds (5 bales) of fibre per acre, and the return on some plots was at the almost unheard-of rate of 34 maunds (nearly 7 bales) per acre. These latter plots were specially treated of course ; but even under the most favourable circumstances such a crop could only be hoped for from a race

which is a very heavy yielder indeed. As a result there is now a distinct and increasing demand for this seed from cultivators in the neighbourhood of the Dacca Farm. In other districts Departmental demonstration plots have been the means of creating a demand. This, for instance, is the case at Barisal, where 50 maunds of seed have been asked for next season, and also in the Rangpur and Purnea districts. Again at Narayanganj in 1915, Mr. J. Luke of Messrs. Sinclair, Murray & Co., sowed a field of 7 bighas with Dacca seed. The soil of the field was not uniformly good, but an average yield of nearly 9 maunds a bigha (27 maunds per acre) was realized. The crop was inspected by a large number of people, and Mr. Luke has sold 15 maunds of seed this year—sufficient to sow about 150 acres—to cultivators living in his immediate neighbourhood. Practical evidence of this kind confirms the conclusion which our experimental trials, already described, led us to, but we do not yet claim to have reached finality in the matter of heavy yielding races of jute. In spite of the great number of varietal trials already done, it is certain that some races in such a large area have hitherto escaped us, and it is quite possible that one or two of these may be better than ours and continual efforts are being made in this direction.

It is necessary to consider another aspect of the varietal problem, and in this connection to remember the considerable climatic differences which exist in the jute tracts. Starting in the north-east the total rainfall shows a continual tendency to diminish as we progress towards the south-west; but the most important difference between East and West Bengal is in the matter of early rainfall, which is characteristic of the former and largely lacking in the latter. Sowing time is thus markedly later in Western than in Eastern Bengal, and as these conditions do not suit *C. capsularis* so well as *C. olitorius*, the latter is the typical jute of Western Bengal. This has necessitated a separate scheme of selections for Western Bengal, and the seed of pure lines of *C. olitorius* is now in course of multiplication. It is conceivable also that the same race of *C. capsularis* will not do equally well all over Northern and Eastern Bengal; no definite indications of this have as yet been

noticed, but the field tests will eventually give us the necessary information. Of course it is far more satisfactory to have to deal with the seed of only one race of each kind of jute; with more than one there would always be considerable danger of mixing the seed; and the precautions which it would be necessary to take against such a fatal contingency would greatly increase the difficulty of the work. It will be seen from what I have said that the work of the Department has now advanced to the stage where further progress, not only with jute, but with rice and in other directions, depends to a large extent on the efficiency of the channels by which we communicate the valuable information we possess to the cultivator and thus induce him to take advantage of it. The Department is already in possession of a district staff of three grades in charge of the Deputy Directors: this staff is doing excellent work, but as some men have to be trained as demonstrators and, even more difficult, others have to be trained to supervise them, it is obviously impossible to increase the district staff indefinitely in a short space of time: to do so would, by producing bad work, do more harm than good. Perhaps, however, the necessity for deliberate rather than rapid action in the formation of an efficient demonstration staff is not a misfortune; for those who are interested almost equally with the ryot in improved agriculture and consequently increased yields of produce, I mean the commercial community, have commenced in no uncertain manner to give us practical help of the most valuable kind. The writer has always held that the jute trade through its mofussil agencies is capable of giving more powerful help to the Agricultural Department in the matter of demonstration of improvements than any other means at present at command. The reasons are numerous, firstly, because there are always at the agencies responsible men who are not only able but willing to give that constant supervision without which, for various reasons, failure comes only too often; secondly, the jute agencies are centres to which large numbers of people come from far and near; most of these people are directly connected, not only with the commercial side, but with the actual cultivation of jute; and many are themselves men of considerable influence. A further important point

is that the prestige of an old established firm is lent to the field work carried out under such auspices. Mr. Suttie, of Messrs. Sinclair, Murray & Co., and Mr. Ross Smith, of Messrs. Bird & Co., attended the Inter-Provincial Jute Conference held at Calcutta in August, 1915, and the above points were brought forward in the course of discussion. The result has been that over 20 plots of land near mofussil jute agencies in all parts of the jute districts have been placed at the disposal of the Agricultural Department in the present season, and Messrs. Suttie and Kinmond Luke (Landale and Clarke) have spent a great deal of time and trouble in making satisfactory arrangements in regard to land, labour, etc. Managers at the respective agencies have also, without exception, taken up the scheme with enthusiasm: the various agricultural operations have been satisfactorily carried out: the plots carry good crops, and valuable results are bound to accrue.

The plots are distributed as follow:—

Names of places	Messrs. Sinclair, Murray & Co.	Messrs. Landale and Clarke, Ltd.
Narayanganj	2	1
Mymensingh	1	1
Sarisabari	1	1
Serajganj	1	1
Rajshahi	...	1
Saidpur	1	..
Darwani	1	..
Jalpaiguri	1	...
Haldibari	...	1
Chattelpara	...	1
Niklidampara	1	
Akhaura	1	...
Ashuganj	1	..
Chaumuhani	1	
Chandpur	2	.
Madaripur		1

In addition Mr. Ducat, of Messrs. Bird & Co., has a large plot of about 7 bighas at Narayanganj, and the Fort Gloster Jute Mill Messrs. Kettlewell, Bullen & Co.) has also a plot at Boureah near Calcutta. The actual alignment of the plots and also decisions regarding the application of manure are in the hands of the Agricultural Department, which advises the managers through the Fibre Expert and the Deputy Directors and their respective staff of

Divisional Superintendents and District Agricultural Officers. A Departmental Demonstrator is also posted at each agency where there are plots ; his duty is to assist the manager in supervising the cultivation and reaping of the crop : arrangements regarding labour, cultivation, etc , in the hands of the agencies , thus the whole scheme is one of collaboration, and it is difficult to over-estimate the value of the work which it will be possible to do

The question of producing a sufficient quantity of seed at a reasonable price contains some points of interest. It is worth noting in the first place that jute and hemp offer greater difficulties in this respect than any other crop. In the case of cotton, for instance, the lint is always obtained with the seed ; with flax a certain proportion of seed is always obtainable, and the same refers to grain crops where the seed is at the same time the object of selection and the article of commerce. With jute and hemp the plant as a fibre-producer is ready to cut before even the seed pods have formed, and by the time the seed is ripe it is possible to extract the good fibre from the plant. Again it is a well-known fact that, on the whole, a dry climate produces not only a heavier yield, but better grain than a wet climate. If there is heavy rain at the time of flowering, pollination cannot take place so freely and many flowers do not set seed, the result being a diminished yield of grain. It is recognized that heavy rain at flowering time diminishes the yield of rice and the same is true of jute. In the damp climate of Eastern Bengal 3 maunds an acre may be taken as something like an average yield of jute seed ; in Western Bengal about 5 maunds might be expected, while in Bihar from 8 to 10 maunds per acre have been reaped from blocks of several acres. It is obvious, therefore, that seed can ordinarily be produced in Bihar at a cheaper rate than in Bengal. Moreover, the germination capacity of seed grown in the dry climate is often better than that produced in a moist one, for a day's heavy rain about the middle of October, or little later, when seed is ripening in the pod, will reduce its germinative capacity very seriously indeed. If a dry climate is suitable for the production of seed, a damp one such as that of Eastern Bengal is equally fitted for the development of the heavy mass of vegetable

matter which is required in a crop of jute grown for fibre. Therefore, at a time where there is none too much jute, and bearing the above facts in mind, it is a matter for consideration whether, if a very large quantity of seed is required, it should not be produced in other tracts than the jute districts of Bengal.

I have now described in some details the present position in regard to the production of improved seed; this, however, is only one side of the work which is being done; there undoubtedly lies at least as great scope for increased crops in an improved system of cultivation and manuring. Results of value have already been obtained, and these are being successfully passed on to the cultivator through the demonstrating staff. But the problem of manures and implements differs from that of seed, in that the former involved a considerably greater outlay of ready money which the Indian cultivator is not usually blessed with. For the development of this side of its work the Agricultural Department looks to the help of the co-operative credit societies. United action on these lines has already begun, and the ultimate result, as far as jute crop is concerned, will be at least as great as that obtained by the introduction of pure seed. From the latter an increased average yield of about 1½ maunds per acre, say, nine lakhs of bales, seems well within reason. The aggregate annual value of such an increase can safely be put at 4½ crores of rupees or about £3,000,000, and as equal increment could be credited to other improvements, we may ultimately look for an increased yield of about twenty lakhs of bales of fibre per annum worth roughly 9 crores of rupees or £6,000,000. All this will take time, but we feel that we are working on the right lines.

THE MILKING MACHINE IN INDIA.*

BY

H. ST. JOHN.

IN several Indian periodicals and journals we have noticed lately articles advocating the advisability of the introduction of "Milking Machines" into India.

From a perusal of the Home and American periodicals, and reports of trials of the machines, there is no doubt that within the past two or three years many important improvements have been added which greatly tend to increase their efficiency.

There is no doubt in the minds of experts that the milking machine has come to stay, and that its use will in the future supersede to a great extent milking by hand-labour.

From the Home reports there would appear to be two schools of opinion regarding their utility : those in favour of their use have undoubtedly good reasons for their opinions derived from experience gained from actual working conditions ; those against the introduction of these machines also arrive at the conclusions in the same way and possibly with the same machines as those reported favourably on by those in favour of them.

Practically all the failures are traceable to some physical characteristic of the cow or incompetence of the operator, a want of knowledge of the working conditions of the plant, and careless manipulation of the working parts, and incorrect adjustment of the machine.

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* Reprinted from *The Journal of Dairying and Dairy Farming in India*, vol, III, part IV, July 1916.

Without the co-ordination of the operator the results must inevitably end in failure.

It is therefore necessary that the operator should thoroughly study his machine and harmonize its working to suit the individuality of the cow. The milk is secreted in the mammary gland and is a natural function not controlled by the cow or the operator.

The secretion of the milk is connected with the nervous system of the cow which the milking operator may affect but not control.

If the animal is frightened, or roughly handled, it must affect the secretion of the milk, and although in isolated cases this would probably have only a temporary adverse effect on the yield, if continued, normal yield would not be obtained.

There is also another most important point to be studied. The flow of the milk from the upper to the lower part of the udder is controlled by the cow. The secretion of the milk in the mammary gland is chiefly in the upper portion of the udder.

The reservoir for the milk is just above each teat, connected by a system of tubes or vacuoles. These are servers to conduct the milk to the cow's udder. The milk ducts branch and rebranch, the opening and closing being controlled by the cow.

If the machine is badly fitted or controlled and the cow suffers discomfort, she will hold up the milk, thus causing longer time to strip her, or if not thoroughly stripped, will eventually cause her to dry off.

The individuality of the cows is another important factor in the milking machine use. In the first part of the lactation period the animals are almost nearly all alike.

As they advance in the milking period the animals develop peculiarities and characteristics which the operator must closely study, and adapt his operations to meet them.

It is most important to see that the teats are in normal condition before putting on the teat cups, so that the cups get a straight and proper grip on the teats.

The pulsator should be worked to meet the characteristics of the cows, and not at a uniform speed for each and every animal.

Then, again, some cows give their milk more rapidly than others, and so to ensure the success of such operations it is necessary to give these few points very careful attention.

To those dairymen in India considering the advisability of the introduction of these milking machines it is most emphatically pointed out that the most careful study in the working conditions is absolutely necessary. In India we often consider that the introduction of machinery requires very little care beyond the starting and closing operations. We consider that when these points are properly carried out no further adjustment, control, and adaptability to local conditions are necessary.

The machine or plant is then condemned as being useless, whereas in the hands of a careful and intelligent operator success with the same machine is assured.

With the introduction of these machines into India, it must be remembered that the cow is not an inanimate object, but a living individual requiring control and careful consideration of her characteristics and peculiarities.

The conditions of Indian labour make it certain that sooner or later the milking machine will be introduced into India, and its introduction will be in time a great factor in the dairying industry of this country. The difficulty of obtaining really good milkers is more apparent year by year. The *gowalla* we knew a few years ago, whose forefathers were milkmen for generations, is dying out. The younger generations are taking up other employment in the large cities of the Empire.

It will, therefore, be absolutely necessary in large dairies to train men to milk, and when that time comes it will be profitable to look around for some other addition to take the place of hand milking. The milking machine, adapted to Indian conditions, will then force its way to the notice of the Indian dairyman.

To ensure success the introduction should be gradual, taking a few cows at a time, and continuing until all the various points in good working are thoroughly mastered.

To install a machine in an Indian dairy and expect success from the machine within a few hours of its installation will

undoubtedly cause failure and the introduction on a large scale of a really excellent method of economical working must be delayed.

As a trial machine is to be installed in India shortly, we hope to be able in a subsequent issue of this journal to give some reliable data on the working of these machines, under Indian conditions, and with Indian animals.

FOOD AND WORK.*

MUCH of what we know about our food has been derived from empiric experience handed down to us for ages. With the knowledge so acquired the human race, under normal conditions, got along comparatively well. In consequence, little attention was given to the scientific investigation of food problems until within the last half-century. Even now the lack of knowledge amongst well-educated people of the composition of foods and their relative nutritive values may not inaptly be compared with that which prevailed in respect to fresh air and ventilation before the discovery of oxygen and its use in breathing. It is not the purpose of this article to trace the various steps by which the gaps in our knowledge of food requirements have been filled. But one important discovery of no distant date deserves mention, namely, that each of our foods has its own particular value in respect to the production or output of work by the human body. A consideration of this aspect of food problems is nowadays of vital consequence to a people, which for the most part is at work to maintain its national existence.

But before referring to the energy-value of foods it should be remembered that the human body, in common with that of every living being, suffers continuous loss every day, due partly to wear and tear of its structure, partly to the performance of work, and partly to the production of heat for maintaining body warmth. This loss is made good by food, which therefore has several functions to fulfil, namely, to supply material for structural repair and in early

* Reprinted from *Nature*, dated 14th December, 1916.

life for growth, to provide energy for the performance of work, and, lastly, to furnish fuel for the maintenance of heat.

FOODSTUFFS.

If an ordinary suitable diet be examined it will be found to contain certain classes of substances known as "foodstuffs," which have been proved to be necessary for nutrition. The first of these is exemplified by the lean of meat, the white of egg, the casein of milk, the gluten of flour. These are the proteins or albuminous foodstuffs, and it is only from one or other of these that nitrogen can be obtained to nourish the animal body. A certain amount of this class of food is therefore indispensable, and cannot be replaced by any other. But proteins are not all equally valuable. Some, such as gelatin, can supplement other proteins in supplying nitrogen, but by themselves are unable to sustain life ; they are "inadequate" proteins. Others, such as the gliadin of wheat and the legumin of peas, are "adequate" to provide for maintenance, for energy, and for heat formation, but not for growth. Still others, such as the casein of milk and the glutenin of flour, are adequate for all these purposes, and for growth as well. Inadequate proteins lack one or more ingredients indispensable for nutrition. It is desirable, therefore, to vary the diet in order to secure a sufficient amount of adequate proteins.

The second class of nutrient substances comprises the fats and oils. These serve to supply energy which may be transformed into either work or heat, or partly into one and partly into the other. A certain amount of fat is necessary for health, but it is, to a large extent, replaceable by foods of the following class, namely, starches and sugars. Fats, like proteins, are derived from both animal and vegetable sources. Most foods contain fat in a form not visible to the naked eye.

The third class of substances in our diet, necessary for healthy nutrition, includes starch and sugar. These are known as carbohydrate foodstuffs. They are used solely for the performance of work and the production of heat, and are not stored as such to any extent in the human body. But if taken

too abundantly or by those who lead sedentary lives they may be converted into fat, and are then stored up in this form.

A suitable diet must also supply a certain amount of mineral salts, such as phosphate of lime, and many others, which enter into the composition of flesh and other body-tissues. These are contained in most articles of diet in sufficient quantities, and hence (with one exception, namely, common salt) are not specially added to the food.

Lastly, it has been found by recent investigations that to maintain health our food must contain certain accessory substances, the nature of which is not fully known, but the lack of which brings about diseases, such as polyneuritis or beri-beri, scurvy, and possibly rickets. These substances, known as "vitamines," are present in minute but sufficient quantities in most natural foods. They are, however, liable to be removed in the process of manufacture or destroyed in the preparation of foods. Hence it is desirable that the daily diet should include some raw food, such as salads or fruit. All vitamines are not killed by the cooking of food; some are undoubtedly thermostable.

An adequate diet must not merely include the foregoing classes of foodstuffs, mineral salts, and vitamines, but must supply them in certain proportions and in sufficient quantities to cover the daily expenditure of material and energy which the body sustains.

Availability of Foods.

Before inquiring how these proportions and quantities have been ascertained, it should be remembered that all the food taken into the body is not utilized. The greater part is absorbed and used up or oxidized in the body-tissues, but part is rejected as waste. The proportion of the former or available fraction is higher in the case of animal than in that of vegetable foods. Thus, for example, of meat protein 97 per cent is absorbed, of cereal protein 85 per cent, and of leguminous protein 82·5 per cent.

The average absorption of nutritive substances from different classes of foods is as follows :—

	Protein per cent	Fat per cent	Carbohydrates per cent
Animal foods (meat, eggs, milk)	97	95	98
Vegetable foods	85	90	97
Ordinary mixed diet	92	95	97

THE DAILY EXPENDITURE OF ENERGY.

The quantities of different foodstuffs necessary for a day's ration have been determined in various ways, such as by ascertaining the average consumption per head of different classes of the community, or of the inmates of large public institutions, or, lastly, of the population of whole towns or countries. This has been supplemented and confirmed by "balance" experiments, in which the amount of food required to keep the body in equilibrium under different conditions without gain or loss of weight has been determined. But the most fruitful of all our information has come from a comparison of the energy expended in different ways by the human body, with the food requirements necessary to meet it. In this matter we have only to deal with three forms of energy :—(1) Latent or chemical energy contained and supplied in our foods ; (2) mechanical energy available for the performance of useful work ; (3) heat energy furnished by the burning or oxidizing of food within the body and used to maintain its normal temperature. The first-named represents the income side of the energy balance-sheet, the last two the expenditure side.

Each foodstuff has its own energy-value. This has been ascertained by burning a known weight of the dried material in a suitable calorimeter, and finding out how much heat is thereby generated. The unit of energy employed in these measurements is the quantity of heat required to raise the temperature of 1 kilogram of water from 15° to 16° C. It is known as the Calorie (written with capital C), or large calorie, to distinguish it from the small or micro-calorie used in physical measurements.

Food, when oxidized or burnt in the human body, generates the same amount of heat as when burnt to the same degree or state in the calorimeter. This has been abundantly proved by experiment and with surprisingly accurate results. Thus 10 grams of

sugar yield 41 Calories of heat when burnt in the calorimeter. If added to the diet of a resting man, the additional heat generated by his body is exactly the same, the difference not exceeding one-tenth of 1 per cent. The energy-value to the human body of 1 gram of protein foodstuff has been found to be 4·1 Calories, of 1 gram of fat 9·3 Calories, and of 1 gram of starch or sugar 4·1 Calories.

The daily expenditure of energy by an average man, living at ease, is as follows in a temperate climate :—

	Calories
Radiation of heat from the body as ordinarily clothed (64 Calories per hour) ...	1,536
Evaporation of water at skin and lungs ...	611
Heating of respired air ...	80
Heating of food and drink to body temperature ...	53
Work of the heart and muscles of respiration, etc. ..	150
Total ...	2,430

Less than the above—namely, about 2,000 Calories—is expended by a man at absolute rest, such as when lying in bed; considerably more when work is performed. The addition for hard but not excessive work amounts to 1,400 Calories. Consequently, to meet this expenditure, a working-man must be provided with more food to keep up the income side of his energy balance-sheet, the additional amount required being determined by the severity of the work and the conditions under which it is performed.

The Daily Food Ration.

For an ordinary day's work of eight hours in this climate, it is reckoned that a man of average weight should receive, in his daily food, from 3,200 to 3,300 Calories of *available* energy. A woman requires somewhat less, namely, 0·8 of a man's ration, or 2,560 to 2,640 Calories.

The former is provided by a ration which supplies the following :—

	As eaten, grams	As digested, grams	Net Calories
Protein ...	100	92	377
Fat ...	100	95	883
Carbohydrate ...	500	485	1,988
Total ...			3,248

It need scarcely be said that to make out a ration of this kind a table of food- and energy-values such as is exemplified in the following short list is needed :—

Composition and Energy-value of Some Common Foods.

	Per cent			Per pound weight			
	Protein	Fat	Carbo-hydrates	Protein, grams	Fat, grams	Carbo-hydrate, grams	Energy-value, Calories
Beef (medium fat)	.. 15·0	18·0	—	68·0	81·6	—	1,039
Mutton ...	.. 13·5	25·0	—	61·2	110·9	—	1,282
Bacon (average) ...	.. 9 5	59·4	—	43·0	270·0	—	2,687
Herring (edible portion)	.. 19·5	7·1	—	88·4	32·2	—	652
Bread ...	.. 8·0	1·2	52·5	36·3	5·4	238	1,175
Milk ..	. 3·4	4·0	5·0	15·4	18·1	22·7	325
Eggs ...	.. 12·0	9·5	—	54·4	43·1	—	624
Cheese (full cream)	.. 25·9	33·7	2·4	117·5	152·8	10·9	1,950
Oatmeal ...	.. 16·1	7·2	67·5	73·0	32·6	306·2	1,860
Potatoes	. 1·75	0·1	21·0	7·94	0·46	95·3	427
Peas (green)	.. 7·0	0·5	16·9	31·75	22·70	96·6	465
Peas (dried)	.. 24·0	1·5	60·0	108·8	6·8	272·2	1,626
Butter ...	. 1·0	85·0	—	4·5	381 5	—	3,600
Margarine	. 1·2	84·0	—	5·4	381·1	—	3,566
Dripping	. 0·25	96·45	—	1·1	437·5	—	4,068

Allowance has also to be made for waste in food purchased, such as bone, gristle, surplus fat, etc., of meat ; skin, rind, core, etc., of vegetables. Langworthy calculates that a ration of 3,200 Calories *utilized* corresponds to one of 3,500 Calories as *eaten*, and of 3,800 Calories as *purchased*.

THE FOODSTUFFS AND ENERGY-VALUE OF THREE ORDINARY MEALS.

The following gives an illustration of how the foodstuffs and food energy necessary for an average day's work are distributed over three simple meals. But it is not to be understood that this is in any sense an ideal set of meals.

BREAKFAST.

Food	Protein, grams	Fat, grams	Carbo-hydrate, grams	Energy-value, Calories
Bacon, 2 oz.	5·37	33·75		336
1 egg	6·55	5·40		78
Bread, ¼ lb.	18·15	2·70	119·0	588
Butter, ½ oz.	0·14	12·00	—	112
Tea, sugar 1 oz., milk ¼ pint ...	2·40	2·80	32·0	167
Total ...	32·61	56 65	151·0	1,281

DINNER.

Food	Protein, grams	Fat, grams	Carbo-hydrate, grams	Energy-value, Calories
Beef, ½ lb.	34·00	40·80		519
Potatoes, 1 lb.	7·90	0·46	95·26	427
Vegetables, 2 oz. ...	0·43	0·08	2·26	12
Bread, 2 oz.	4·53	0·65	30·00	147
Cheese, 1 oz.	7·10	8·50	0·70	111
Tapioca pudding, 3¼ oz. ...	3·30	3·20	28·20	159
Total ...	57·26	53·69	156·42	1,375

SUPPER.

Food.		Protein, grams	Fat, grams	Carbo-hydrate, grams	Energy-value, Calories
Porridge (oatmeal, 2 oz.) ...	...	9·10	4·07	38·30	232
Bread, ¼ lb.	...	9·07	1·35	59·50	294
Butter, ½ oz.	...	0·14	12·00	—	112
Milk, ½ pint	...	9·60	11·30	14·20	203
Jam, 1 oz.	...	0·20	0·03	14·10	59
Total	...	28·11	28·75	126·10	900
Total for 3 meals	...	117·98	139·09	433·52	3,556

To be relished, foods must be appetizing and well cooked, and if good digestion is to be secured and retained, the meals must not be hurried over. It is of the greatest importance, therefore, that attention be paid to the cooking and serving of meals, and that time be taken for their enjoyment.

HUMAN EFFICIENCY.

If the table of expenditure of energy by the human body be referred to, it will be seen that more is lost in the form of heat than in any other way. In fact, the proportion of the whole food energy which usually reappears as useful work is only from 10 to 15 per cent of the intake. This, it may be recalled, is the case also in the ordinary locomotive or other form of heat engine. The matter may, however, be looked at in another way. For mere maintenance at complete rest the human body requires an intake of 2,000 Calories, for maintenance at ease 2,400 Calories, and for hard work an extra intake is needed of 1,400 Calories. Of this extra intake of energy—the price paid for work—400 Calories (28·5 per cent) ordinarily reappears as useful mechanical work, and would correspond to 170,000 kilogram-metres or 1,220,000 foot-pounds for a day's work of eight hours, to a condition of moderate fatigue. The human body has the power, however, of working more economically when severe and prolonged strain is required. Under such conditions it has been ascertained that one-half or even more of the chemical energy of the additional food taken may reappear in the form of useful external work. The human machine, all things considered, is therefore a very "efficient" one when at work, though an expensive one to maintain in idleness. W. H. T.

THE INFLUENCE OF SUGAR BEET CULTIVATION ON GERMAN AGRICULTURE.*

A Board of Agriculture Study.

The Board of Agriculture since the war broke out has, under the able presidency of Lord Selborne, taken steps to make a study of the development of German agriculture covering the last thirty or forty years. The result of these investigations has just been published in the shape of a valuable paper[1] prepared by Mr. T. H. Middleton, C. B., an assistant secretary of the Board. What he has to say about the beet sugar industry, for instance, is reproduced below, and will be read with profit by all interested in the subject, though much of its information is nothing new to those who have carefully followed the trend of German beet agriculture during the last few decades. The lesson to be learned from it is at least two-fold: technical methods and scientific co-operation have resulted in a standard of intelligent cultivation in Germany such as our own agriculture can hardly touch; and there the State, far from pursuing a *laissez faire* policy, has long taken an active interest in its indigenous agriculture, and has assisted by means of fiscal and political expedients in stimulating the popular exertions to produce the desired end. The result is that in the United Kingdom, even in those crops which rank as staple, the output per acre is a good way short of what the German farmer achieves. But if the latter is more progressive, it is largely due to the State which first ensures him a practical education, and then offers him encouragement to make the most industrially of his knowledge.

"Germany has been successful in founding some important industries in direct association with agriculture. In addition to

* Reprinted from the *International Sugar Journal*, vol. XVIII, no. 212, August, 1916.

[1] Board of Agriculture and Fisheries. Cd. 8305. Price 5*d*. post free.

the brewing and distilling industries, there is the beet sugar industry, a considerable potato-starch industry, and a rapidly growing potato-drying industry. These industries have had a very considerable influence in developing agriculture ; they have been directly effective by providing local markets for agricultural produce, and indirectly useful in supporting a rural population which provides agriculture with much occasional labour at busy seasons. In the latter respect, the beet sugar industry is especially valuable, for the factory campaigns are carried on from November till the end of January, just at the time of year when employment is most needed by rural workers. The beet sugar industry has exercised so important an influence on the rural economy of Germany that some further reference to the crop may be made with the object of illustrating German technical methods.

" It is generally admitted in Germany itself that sugar beet has been of immense service to agriculture. The following quotation from Helfferich shows the view taken of it by business men. ' In addition to the immediate profits derived by German agriculture from the increased production of beet sugar, the cultivation of the beetroot has brought large remoter advantages. The intense and intelligent cultivation required by the beets proved everywhere an advantage for the other branches of agriculture.'

" In the discussions on the value of the sugar beet to the British farmer which have taken place in recent years, it has frequently been stated that while beet is an expensive crop to grow, the gross value is small compared with that of certain other farm crops. Thus an acre of beet, which costs £9 to £11 to grow, may be worth only £10 to £12. The mangold crop which costs less to cultivate is worth more in some districts for cow feeding, and the gross value of an ordinary potato crop is often considerably more. Thus, it has been argued that beet is a crop worth attention only when labour is cheap and the soils are not adapted for potato growing. The relatively low gross value of beet cannot have escaped attention 50 years ago when the crop was fighting for a place on the German farm, but the considerations which have told against beet

in recent years in England have not prevented it from becoming the popular root crop on the best land of Germany.

"Beet, like other crops, requires well-defined conditions if it is to be grown to perfection; these conditions do not exist all over Germany, but where they do, beet culture has made rapid progress, and the production of raw sugar is now ten times as large as it was 40 years ago.[1]

"With the object of showing the agricultural importance of the beet crop, I have collected the following figures which compare the increase in rents and the value of land in certain adjacent Prussian districts (*Regierungsbezirke*). In the first three districts, Magdeburg, Merseburg, and Hildesheim, from 7 to 10 per cent of the cultivated land grows beet; in the remaining four—Erfurt, Potsdam, Frankfurt, Liegnitz—the crop occupies only from 0·7 to 1·4 per cent of the cultivated area. In other respects the cropping is similar; in all districts the potato is an important crop claiming from 9·3 to 19 per cent of the land, while cereals occupy from 55 to 61 per cent.

Rent and Land Value in (1) *Beet Growing,* (2) *Non-Beet Growing Districts of Prussia.*

District		Cropping per 100 acres of Arable Land (1900)			Rent per acre			Value per acre of Estates of over 1,250 acres	
		Beet acres	Potatoes acres	Cereals acres	1867	1907	Increase per cent	(1895—1905)	
					s.	s.		£	s.
Magdeburg ...	Much Beet grown[2]	10·5	14·0	56	18	36	100	55	0
Merseburg ...		7·0	12·5	60	16	27	69	33	4
Hildesheim ...		9·7	9·3	61	...	30	...	45	16
Erfurt ...	Little Beet grown.	1·3	11·9	56	13	14	8	20	16
Potsdam ...		1·0	16·0	56	9	10	11	14	6
Frankfurt ...		0·7	19·0	55	10	13	30	12	19
Liegnitz ...		1·4	15·0	60	9	14	55	15	7

[1] See Table at end.

[2] By 1913 the percentage of area under beet in these districts had risen to: Magdeburg 11·8 per cent, Merseburg 8·8 per cent, Hildesheim 10·2 per cent.

"Column 7 of the statement shows that in the forty years (1867—1907) rents rose from 69 to 100 per cent in two of the three beet-growing districts and from 8 to 55 per cent in the four non-beet-growing districts; further, it will be seen from column 8 that, at the beginning of the present century, the value of land in the beet districts was very much higher than in the others. Reviewing all the figures in this statement, two conclusions may be drawn, *viz.*, that beet is now a favourite crop on the best land in Prussia, and that, since beet growing developed, the value of this land has increased to a much greater extent than the value of land in adjacent districts less well suited for beet cultivation. Examination of the productiveness of the districts in question does not modify the conclusion that beet, not the potato (in England accounted the more profitable), determines the value of the land. Potsdam, for example, had 16 per cent of the cultivated land under potatoes, Magdeburg had 14 per cent; the fields in the latter district are but slightly better than in the former, and if the potato were the crop which determined the value of the land, the difference in value between the two districts should have been much less.

"The importance of the sugar beet crop was recognized in Germany at an early stage, and its development has been carefully fostered by duties and by-laws calculated to assist the industry. The first German excise on home-grown sugar took the form of a tax on raw beet, which gradually rose from one mark per metric ton in 1841 to 18 marks in 1888. This method of taxing raw beet was apparently inimical to the interests of growers, and was much criticized, but it had the advantage of putting a premium on roots of high quality and stimulating selection in the production of seed. The great improvement in the quality of the roots which resulted from continuous selection has since contributed in a marked degree to the success of the industry. (Helfferich points out that whereas in 1875-76 it took 11·62 tons of beet to produce one ton of raw sugar, in 1910-11 only 6·08 tons of beet were required.) In 1892, the merits of selection having meantime been established, the excise duty on beet was replaced by a duty of 18 marks per 100 kg. on raw sugar; this duty was raised to 20 marks in 1896.

"To assist exporters, refunds of duty of various amounts had been allowed since 1861, and in 1892 a direct bounty was given; but the production of sugar was controlled so as to limit the State's liability for bounty and a small tax was levied on factories. In 1896 the bounty was increased to 2·56 marks per 100 kg. of raw sugar. Under the terms arranged by the Brussels Convention, however, bounties ceased as from 1st September, 1903, and thereafter the protection of German sugar was limited to the extent agreed upon by the parties to the Convention, *viz.*, 6 fr. per 100 kg. of refined sugar (2*s*. 4*d*. per cwt.).[1] Since 1903 the actual import duties on raw sugar have been 18·4 to 18·8 marks per 100 kg.; the excise duty has been 14 marks.

"The excise on sugar is one of the important sources of revenue of the Imperial Government. Its yield rose from £3,168,000 in 1875-76 to £9,441,000 in 1909-10.

"As compared with the 37 million acres under cereals, the total area under sugar beet (before the war about 1,440,000 acres) is small, but as the above quotation from Helfferich shows, the beet crop has exercised a much greater effect on German agriculture than the amount grown would suggest. As has already been indicated, it has brought an important industry and large sums of money to rural districts; it has necessitated deep cultivation and heavy manuring, with most beneficial results to succeeding crops; the beet growers have been the pioneers of improved farming in many parts of Germany; the residues from the crop have been skilfully used for cattle feeding, and animal husbandry has flourished where sugar beet is grown; finally it is recognized as *the* crop which produces most human food per unit of area. Writing in February last to a German newspaper, Dr. Eltzbacher, the Berlin economist and authority on German food production, urges agriculturists to grow more sugar beet in 1916; he describes it as the most nourishing crop grown by the farmer, yielding five times as much food as rye, and twice as much as potatoes from the same area of land.

[1] A country adhering to the Convention is at liberty to impose an import duty of 6 fr. per kg. in excess of any excise duty levied on refined sugar.

"The sugar beet crop occupies less than two per cent of the cultivated land of Germany, but without it the high level to which German agriculture has attained in recent years would have been impossible."

Cultivation of Sugar Beet and Yield of Sugar in Germany during 25 years, 1886-87 *to* 1911-12.

Campaign	Number of Sugar Beet Factories	Area under Sugar Beet (1,000 ha.)	Average yield of Beet per hectare (Metric tons)	Total Sugar (shown as Raw Sugar) obtained from Beet and other Raw Material (1,000 Metric tons)	Weight of Beet necessary to produce 1 ton of Raw Sugar (tons)
1886-87	401	..	30·0	1,018	8·16
1887-88	391	....	26·4	959	7·26
1888-89	396	.....	28·2	991	7·97
1889-90	401	....	32·9	1,261	7·79
1890-91	406	....	32·2	1,336	7·95
1891-92	403	......	28·2	1,198	7·92
1892-93	401	352	27·9	1,231	7·97
1893-94	405	386	27·5	1,366	7·79
1894-95	405	441	32·9	1,828	7·94
1895-96	397	377	31·0	1,637	7·13
1896-97	399	425	32·3	1,821	7·53
1897-98	402	437	31·3	1,844	7·43
1898-99	402	426	28·5	1,722	7·05
1899-1900	399	427	29·2	1,795	6·93
1900-01	395	448	29·6	1,979	6·70
1901-02	395	479	33·4	2,302	6·96
1902-03	393	428	26·4	1,789	6·30
1903-04	384	417	30·4	1,921	6·60
1904-05	374	417	24·2	1,605	6·27
1905-06	376	472	33·4	2,401	6·55
1906-07	369	447	31·7	2,242	6·33
1907-08	365	450	30·0	2,139	6·30
1908-09	358	436	27·1	2,079	5·68
1909-10	356	458	28·2	2,037	6·33
1910-11	354	478	33·0	2,590	6·08
1911-12	342	505	18·0	1,498	6·05

Notes.

THE FEEDING VALUE OF "BHUSA."

It is hoped that the whole subject of the feeding of cattle in India will eventually be thoroughly investigated by an Imperial Specialist and reliable data established. In the meantime, however, it is felt that such experience as can be gained by simple experiments is of assistance, in some cases as a guide to practice, in others in connection with students' lectures. A series of such simple experiments are being conducted with the cattle at the Lyallpur College and Experimental Station whenever an opportunity occurs of doing so, without interference with other work in hand. Such an experiment was recently carried out with the object of obtaining figures illustrative of the difference in feeding value between *bhusa* and straw, similar but unbroken. These figures may be of use to others whose duties include the teaching of "principles of cattle feeding."

The method of carrying out the experiment was as follows. Four pairs of working cattle, whose condition and treatment previously had been fairly similar, were selected and weighed. They may be called a1, a2 ; b1, b2 ; c1, c2 ; d1, d2. All were first fed on long straw for eleven days and subsequently one of each pair (a, b, c, d) was fed on *bhusa* for a fortnight, the other one of each pair remaining on the long straw ration. At the end of this fortnight the rations were interchanged.

Weighments were made weekly whilst the experiment was in progress ; but only the fortnightly weighments, when rations were changed, are recorded in the statement below. In addition to the straw or *bhusa* one seer of gram and one seer of barley were given to each bullock every day. When the cattle went to work they naturally went in their original pairs that is a1 with a2, etc. They

Table I.

Group	Bullocks	Kind of food 27-7-16 to 8-8-16	Total quantity.	Average quantity per day per bullock	Weight in lb. on 27-7-16	Weight on 8-8-16 in lb.	Difference in weight in lb.	Average loss (–) or gain (+) per bullock in 11 days	Kind of food 8-8-16 to 23-8-16	Total quantity	Average quantity per day per bullock	Weight on 8-8-16 in lb.	Weight on 23-8-16 in lb.	Difference in weight in lb.	Average loss (–) or gain (+) in weight per bullock in 15 days	Kind of food 23-8-16 to 7-9-16	Total quantity.	Average quantity per day per bullock	Weight on 23-8-16 in lb.	Weight on 7-9-16 in lb.	Difference in weight in lb.	Average loss (–) or gain (+) per bullock in 15 days
1	a_1	Straw	mds. 7 seers 13	12 lb.	1092	1057	-35	-15½lb.	Straw.	mds. 10 seers 25	16 lb.	1057	1016	-41	-13	*Bhusa*	mds. 11 seers 15	15 lb.	1016	1013	- 3	-14½ lb.
	b_1				873	828	-45					828	795	-33					795	801	+ 6	
	c_1				864	870	+ 6					870	887	+17					887	856	-31	
	d_1				849	861	+12					861	866	+ 5					866	836	-30	
2	a_2	Straw	mds. 7 seers 13	12 lb.	1204	1197	- 7	-14½lb.	*Bhusa*	mds. 10 seers 29	16 lb.	1197	1195	- 2	+10	Straw	mds. 11 seers 21	15½lb.	1195	1120	-75	-41 lb.
	b_2				927	890	-37					890	881	- 9					881	881	=	
	c_2				958	932	-26					932	975	+43					975	914	-61	
	d_2				852	864	+12					864	872	+ 8					872	844	-28	

were sent to work on as few days as possible; but the work on the days when they went was fairly hard—levelling, ploughing, etc

As to the quantity of *bhusa* and straw fed, the following procedure was adopted :—The cattle receiving long straw received an excess of it; the weight of the amount eaten was observed every day, and those fed on *bhusa* received an amount equal in weight to the quantity of straw consumed by the other group the previous day. Thus the weights consumed by each group during each period were, as the figures below show, approximately equal.

Table I (p. 309) gives the weighments and results of the experiment; Table II shows the number of days' work performed by each pair in each period.

Table II.

Pair	Number of working days in 1st period	Number of working days in 2nd period	Number of working days in 3rd period
a_1 a_2	8 days	6 days	11 days
b_1 b_2	5 "	7 "	13 "
c_1 c_2	6 "	7 "	13 "
d_1 d_2	5 "	7 "	13 "

From the Tables it will be seen that the results recorded were fairly consistent and instructive. When fed on long straw two pairs lost in weight, one gained in weight, and of one pair one bullock lost in weight, the other gained. The average total loss by each group is very similar. In the second period, the group fed on *bhusa* gained, while the group fed on straw lost, in weight. In the third period, when the work performed was much harder, the bullocks fed on straw lost much more than those fed on *bhusa*, though both groups lost in weight. It need hardly be pointed out that no significance can be attached to the actual figures recorded for individual bullocks in the absence of data as to the actual measure of work done and the amount of food eaten by each individual bullock; but differences in this respect cannot greatly affect the results for each group which suggest a great difference in feeding value between *bhusa* and straw—[O. T. FAULKNER.]

THE IMPROVEMENT OF COTTON CULTIVATION IN MADRAS.

The Government of Madras have made an allotment of Rs. 51,500 for the improvement of cotton in the Presidency during the year 1916-17.

In the previous two years expenditure of Rs. 46,390 and Rs. 39,699 was incurred. The receipts, however, amounted to Rs. 41,257 and Rs. 32,389, which left only a deficit of Rs. 12,443, in these two years. This is a small outlay, and when one looks to the substantial results achieved, one cannot but congratulate the Madras Agricultural Department on the success of these experiments. It is anticipated that in 1916-17 also receipts will go a large way towards reducing the net cost to Government.

Mr. Chadwick's report on the operations of his Department to improve the cotton cultivation during the year 1915-16 is of very great interest and shows how much the cotton cultivator has been helped by the Department. A brief resumé of the activities of the Department in this connection will place in proper perspective what field there is for improving the material condition of the Madras cultivators by the introduction of superior strains and improvements in the methods of cultivation of this crop.

Work on cotton is principally confined to Tinnevelly, Bellary, and Kurnool. In Tinnevelly District the main lines on which the work is in progress are :—

(1) General improvement in the purity of the crop by selling seed from bulk selection.

(2) The testing, development, and distribution of unit strains.

(3) The fostering of co-operative sale of pure crops direct to the large firms.

(4) The spread of the use of seed drill and harrow.

In this district, the practice of growing mixed crops of *Karunganni* and *Uppam* was very common. The first work of the Department was to restore the position of *Karunganni* and to evolve by plant selection better and superior strains of this type. After eight years' work, three new types called Company No. 1, No. 2,

and No. 3 have been evolved which are considered superior to ordinary *Karunganni* in point of purity and length and strength of staple. Of these three, Company No. 3 is found to give better yields per acre and more percentage of lint to *kappas* than the other two varieties. The cotton buyers also appreciate the superior qualities of the selections, and offer better prices for them than ordinary *Karunganni*. In 1913 the premium offered was Rs. 3 per *candy* of 500 lb. which rose in the last season from Rs. 10 to Rs. 13 and even touched Rs. 16. It has been estimated that last season Company No. 3 paid Rs. 11-12-0 more per acre than ordinary pure *Karunganni*.

The extension of the cultivation of these selections by supply of pure seed to the cultivators is now occupying the attention of the Department. It may be noted parenthetically that Company No. 1, although an excellent cotton, does not compare favourably with Nos. 2 and 3, and its distribution has therefore been withdrawn. To obtain pure seed for distribution, seed farms have been opened in different localities. These farms are, practically speaking, not Government farms. Ryots are supplied with seed on condition that land is cultivated on the methods approved by the Department and that the crop is sold to Government on the terms fixed. This system also serves to demonstrate the improved methods of cultivation. The seed obtained from these farms is then sold to the cultivators. In 1915-16 the Department sold 87,096 lb. of selected seeds of Company Nos. 2 and 3 sufficient to grow 8,706 acres. Besides these the cultivators had already with them the seed of the last year's crop and the total area sown with selected cotton is estimated at 27,000 acres.

The next step is to help the cultivators to obtain the full value for the quality of their crop by inducing them to sell it jointly to the ginning firms direct. But the work is hampered on account of want of unity among the villagers and personal tastes of individual cultivators. The practice is, however, slowly gaining ground as will be seen from the fact that the number of persons who brought their selected cotton direct to the ginneries rose from 3 in 1913-14 to 39 in 1915-16.

Another important work in connection with the improvement of cotton cultivation done by the Department which deserves special mention is the campaign against the cultivation of the low grade variety of cotton locally known as *Pulichai* or *Jari* which was introduced somehow six or seven years ago either from the Central Provinces or Northern India. We give below an extract from the Report of Mr. Chadwick, Director of Agriculture, Madras, which describes fully the efforts of the Department in this direction :—" It (*Pulichai* cotton) is short stapled, very white, harsh, with a fairly clean and somewhat large greenish-brown coloured seed. It belongs to an entirely different class of cottons from Tinnevellies. It does not yield on an average in total weight of *kappas* more than Tinnevellies do ; but the lint out-turn is 30 per cent against ordinary Tinnevellies' 25 per cent. In actual value, when pure, it is only about two-thirds that of Tinnevelly, but it is obvious that if by mixing with Tinnevellies, practically Tinnevelly prices can be obtained for it, it pays to grow it on account of its greater lint out-turn. It is also perfectly obvious that if it became widespread the particular standing which Tinnevellies hold in the world's cotton market would be lost, possibly never be regained. For the last few years the cultivation of this low grade cotton has been extending because Tinnevelly prices were practically obtainable for it. The danger had become serious and imminent. Its presence in Tinnevelly lint had been detected at least once in a consignment sent abroad. Practically every firm interested in Tinny cotton wrote to me last year independently asking that its cultivation should be stopped or at least checked—no easy matter in the circumstances. After some negotiations all buying firms interested in Tinnevelly cotton agreed not to purchase any *Pulichai*, pure or mixed, in the 1917 season. Leaflets were printed in the vernacular and widely distributed before the sowing season in 1916, giving notice of this resolve. Men were sent specially to the villages to dissuade sowings. The Revenue authorities helped. Sowings of *Pulichai* instead of increasing were reduced to one-third of the previous year's and many plants sown by chance were uprooted. It was not, however, eradicated. Especially around Virudupatti and chiefly through the agency of some dealers who gambled

on the agreement breaking down: a considerable area was sown, chiefly mixed. The result was that the early offerings of cotton at Virudupatti—the chief cotton market—all contained some admixture of *Pulichai*. Firms refused to admit any cotton within their yards and the whole market was at a standstill with no money circulating for a fortnight. By that time the very name of *Pulichai* was rapidly becoming anathema to the brokers. This, however, could not hold for ever, and the firms agreed to take such cotton on the sole understanding that the *Pulichai* mixed with it should not be paid for. The pendulum began to swing and it soon became apparent that more stringent methods were needed. All firms then agreed to enter into a formal legal agreement permitting inspection of their yards and books by a selected officer of the Agricultural Department and the imposition of penalties where *Pulichai* had been paid for. I wish to record my great appreciation of the spirit and help with which firms have worked with us towards this object of stopping adulteration, often at much inconvenience, trouble, and loss. I am most indebted to them. There were some who thought we were following a vain hope in endeavouring to stop adulteration, but, by the progress and experience gained, I am sure it can be done. It is, however, absolutely essential to continue effort in its stricter form for another year and to give intimation thereof widely before the next sowing season. It is a straight issue for purity and quality on which both the cotton firms and the Agricultural Department are staking their reputations with the ryots and neither of us can afford to lose them. Meanwhile our selected cottons are coming on more valuable than *Pulichai* and it is largely for this reason that larger seed farms are necessary this year. Meanwhile the Collector of Ramnad, Mr. Loftus Tottenham—who by the by is rapidly becoming an expert in the vegetative characteristic of cotton—is continuing the fight against it in the villages. If it can thus be practically stamped out by this joint action it will be as potent a factor in maintaining the quality of Tinnevelly cotton as anything that can be done on the Agricultural Station by way of selection."

Concurrently with the selection and distribution of seed of pure varieties efforts are being made to improve the agricultural practices

of the tract by the introduction of seed drills and harrows. It may be mentioned that inter-cultivation and efficient tillage are as important in the raising of good crops as is good seed, and the sowing of seeds in lines with bullock hoeing later between them makes for good cultivation. Hence the spread of this system is as much an agricultural improvement as anything else. A few labourers in different villages were trained to the use of these implements and were then employed to teach this method to the ryots in their own and neighbouring villages. This method of bringing home to the cultivators the advantages of this system has been found so successful that the demand for seed drills has considerably increased and the drilled area rose from 7,117 in 1913-14 to 17,060 in 1915-16.

At Bellary and Kurnool the work is confined to the selection and distribution of pure seed of *Sircar* Cotton No. 1 and No. 2, respectively. Here, as in Tinnevelly, seed is given to the cultivators on seed farm conditions. The total amount of seed distributed last year from seed farms was 29,032 lb. in Bellary District and 61,850 lb. in Kurnool District.

The greatest credit is due to Mr. Sampson for evolving Company Nos. 2 and 3 which are replacing *Karunganni* in Tinnevelly District and to Mr. Hilson for the progeny of single plant selections known as *Sircar* Cotton Nos. 1 and 2. It is not too much to hope that the greater profit per acre reaped by the cultivators will, by improving their economic position, make them more ready to assimilate the teachings of the Department in regard to improvements in other crops.—[EDITOR.]

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FEEDING TERMS.

THE following extracts are made from an article on Feeding Terms by B. A. Barr, Senior Dairy Supervisor in the *Journal of the Department of Agriculture, Victoria,* for July, 1916:—

"Simple definitions of the following terms used in stock feeding are offered with a view to assist a proper understanding of the importance of economical feeding, especially when it is necessary to make use of the purchased foodstuffs.

PROTEIN.

"Protein is a term applied to a group of substances present in varying amounts in all foodstuffs. It is composed of the elements carbon, hydrogen, oxygen, and nitrogen, frequently sulphur, and sometimes phosphorus and iron.

"Protein in the food is essential to the building up of flesh, and to milk secretion. The albumen and casein, or curd of milk, are proteins, and the greater the amount of milk yielded the greater will be the amount of protein required in the food. In common cattle foods linseed and coconut oilcake contain the largest amounts; then follow gluten feed polly meal, pollard, bran, oats, crushed maize, green lucerne clover, mixed grasses, green oats, barley, and maize.

"The animal can only utilize economically sufficient protein to repair the wastage of tissues, to promote growth, and to provide for milk secretion. In ordinary feeding, any excess above these requirements is passed off unused. An average dairy cow requires about 0·5 lb. of digestible protein daily for maintenance, and, in addition, 0·04 lb. for each pound of milk. Nevertheless, in making up a ration for milking cows, it is inadvisable to restrict the protein content to the theoretical amount, for two reasons: (1) The food values of foodstuffs vary within wide limits; (2) a slight excess of easily digestible protein possesses a stimulating effect on milk secretion.

"When applied to cattle foods, protein, albuminoids, and nitrogenous substances are synonymous.

CARBOHYDRATE.

"The term carbohydrate is given to a large group of compounds chemically related. They are composed of the elements carbon, hydrogen, and oxygen, and to this class belong sugars, starches, gums, cellulose, etc. In the animal body, carbohydrates are used for the production of energy and heat, and any excess is converted into body fat.

"Unlike protein, any excess of carbohydrates over immediate requirements is not passed off unused, but is stored as a reserve in the form of fat.

"Carbohydrates cannot replace protein, although protein may replace carbohydrate, but only at a high cost.

FAT.

"That obtained from oilcakes, grains, and their offals gives a higher value than that obtained from hays or green fodders. The digestible portion of the ether extract serves the same function as the carbohydrate, but its capacity for heat production is much greater, pure fat having two and a half times the value of carbohydrate. The crude fat or ether extract of oilcakes, grain, bran, etc., possesses a capacity for heat production two and two-fifths times greater than carbohydrate, whereas the fat estimation of hays and green fodders is only about twice the value of carbohydrate.

NUTRITIVE RATIO.

"The nutritive ratio, or N.R., of any food means the ratio of the protein content to the carbohydrate and ether extract combined: the ether extract is reduced to its starch equivalent. The nutritive ration of any food, or combination of foods, is a most important factor in determining its efficiency.

"Milking cows yielding up to 3½ gallons daily are most economically fed on a ration with a N.R. of 1 to 6 or 7, which is the ratio of good mixed pasture grass; but for heavy milkers yielding 4 gallons and over, the ratio may be effectively reduced to 1 to 5, which means that for each part of digestible protein there are 6, 7, or 5 parts of carbohydrate respectively.

"In practice, the N.R. of any ration is valuable when purchased foods are used, because it shows in what proportions the constituents should be combined to produce the best return. Both money and feed may be wasted by disregarding its value. When the N.R. is too wide, the food is deficient in protein, and consequently not sufficient protein is ingested to meet the needs of the animal, whilst at the same time the digestibility of the food is depressed. Maize (green) is an example of a food with a wide ratio, there being 1 part of protein to 12 of carbohydrates. When the ratio is too narrow, protein is wasted, because the amount of food consumed under

general conditions contains a greater amount of protein than the animal can utilize.

"An average milking herd requires food possessing an average ratio of 1 to 6 and 1 to 7. When the amount of carbohydrate is greater, the ratio is wide; when less, narrow.

"Examples of foods, with their ratios :--

Wide N.R.				Narrow N.R.			
Green maize	1	:	12	Green lucerne	1	:	3
Oaten hay	1	:	11	Bran	1	:	4
Oaten straw	1	:	46	Linseed meal	1	:	2
Potatoes	1	:	18	Brewers' grain	1	:	3

"The use of any of these foods alone results in considerable waste, and is not conductive to an economical return; but a combination of the above foods provides not only the necessary food substances but contains them in that proportion which produces the most economical return.

Balanced Ration.

"A combination of foods in that proportion which gives the best results for any particular purpose. Some of the above-mentioned foods, when combined in the following proportion, form a balanced ration for an average milking herd :--

Maize	40	Bra	4	Chaff ...	10	Lucerne hay	12
Bran	10	Green Lucerne	15	Linseed meal ...	1	Maize	50
Chaff		Maize ..	40	Brewers' grain ...	20	Bran	10

The amounts fed are determined by the quantities of milk secreted. It must not be inferred that, when some of the above feeds are fed alone, good returns are not attained, but a combination increases the yield, and at the same time decreases the cost of production when market values are given to home-grown crops, or when purchasing.

Concentrates.

"A term applied to foodstuffs relatively rich in easily digestible food substances, as oilcakes, grains, bran, and mill products. Lucerne hay—although popularly regarded as such—is not a concentrate in

the above definition, owing to the high cost of digestion. It should be used as a bulky feed, and, when farm-grown, should be provided in large quantities.

MAINTENANCE RATION.

"That amount of food required to maintain a non-producing animal in a healthy condition.

"In any system of feeding, the first demand is made for maintenance; what is available over this requirement can be used for work or milk production. In feeding milking cows, the maintenance part of the ration is most cheaply supplied by bulky foods, such as hays and green fodder. That part to be used for milk secretion is best provided by easily digestible concentrates."

These extracts, we feel, should assist many in this country who may know the terms by heart—but have not been able to realize to the full what is meant by them—to grasp the full value of proper feeding of animals—whether for milk, work, or growth—the object of which is to get the greatest results out of the cheapest ration.

Realizing as is all too true that the cheapest ration all round is the perfectly balanced one, which supplies all that is needed without waste either of the animal's tissue or of the owner's money, we are constrained to observe that here in India it is more frequently the tissue of the animal which goes to waste to the detriment of future generations, and a little study of the above will soon show the reason to all interested.—[WYNNE SAYER.]

LIST OF HALF-BRED COWS

*On Government Military Dairy Farms, Southern Circle, which have completed one lactation compared with their dams.**

No.	Description of Cross	Average yield per period, lb.	Average yield of dam, lb.	REMARKS
	Mhow			
320	Ayrshire-Scindi	3,753	2,327	
358	,, ,, ...	3,755	985	
323	,, Saniwal ..	3,001	1,319	
324	,, ,, ..	3,534	795	
326	,, ,, ...	4,599	1,591	
327	,, ,, ...	2,970	1,087	
328	,, ,, ...	4,755	1,765	
351	,, ,, ...	4,098	2,689	
352	,, ,, ...	1,287	1,083	Ist calf
380	,, ,, ...	4,033	1,597	
359	,, ,, ...	1,198	2,000	1st calf.
321	,, Hissar ...	4,104	2,043	
325	,, ,, ...	4,361	1,228	
329	,, ,, ...	3,312	1,464	
	Average ..	3,482·8	1,569·5	
	Kirkee			
1	Ayrshire-Scindi .	4,308	3,229	With 2nd calf given 5,082 and still giving 18½ lb. daily.
2	,, ,, .	3,450	3,229	
3	,, ,, ..	4,503	2,260	
4	,, ,,	3,364	2,578	
5	,, ,, ...	4,367	1,471	
7	,, ,, ..	2,170	1,076	
8	,, ,, ...	3,311	1,683	
14	,, ,, ...	7,310	2,917	
9	,, ,, ...	4,934	2,148	
13	,, ,, .	8,506	2,761	
14	,, ,, ...	3,547	1,986	
16	,, ,, ...	7,500	3,268	
26	,, ,, ..	4,575	2,068	
24	,, ,, ...	5,200	1,973	
6	,, Hansi ...	4,798	2,734	
	Average .	4,789·5	2,358·7	

* Reprinted from *The Journal of Dairying and Dairy Farming in India*, vol. III, part 2, January, 1916.

List of half-bred cows, etc.—(contd.)

No.	Description of Cross	Average yield per period, lb.	Average yield of dam, lb.	REMARKS
	Quetta			
1	Shorthorn-Scindi	3,342	1,749	
2	" "	3,192	1,800	
3	" " ...	3,203	2,140	
4	" " ..	3,562	1,715	
5	" "	3,635	1,632	
7	" " ..	2,799	1,587	
8	" " ...	3,553	2,384	
10	" " ...	2,556	2,082	
12	" " ...	9,315	1,338	
13	" " ...	2,007	1,194	
14	" " ...	4,547	2,006	
15	" " ...	3,033	2,206	
16	" "	3,650	2,500	
18	" " ...	4,180	2,088	
19	" " ...	4,190	1,988	
20	" " ..	3,252	1,304	
21	" " ...	5,708	1,860	
22	" " ..	3,579	2,254	
31	" " ...	3,056	1,980	
	Average ...	3,813·6	1,887·2	
	Bangalore			
253	Ayrshire-Saniwal ...	3,943	1,767	
282	" " ...	4,103	1,654	
290	" " ...	4,283	1,967	
298	" " ..	3,253	1,680	
243	Shorthorn-Hansi ...	2,800	1,700	
257	" " ...	3,531	1,396	
267	" " ...	5,153	1,700	
288	" " ...	3,616	2,000	
293	" " ...	3,653	1 700	
127	Ayrshire-Hansi	4,123	2,044	
131	" " ...	5,000	1,700	
132	" " ..	5,270	2,110	
133	" "	8,489	2,650	
135	" "	3,355	1,540	
136	" "	3,930	1,870	
138	" "	4,685	1,088	
139	" "	4,859	1,560	
140	" "	3,600	2,650	
141	" " ..	5,217	3,841	
241	" " ...	4,614	1,150	
242	" " ...	2,994	1,850	
246	" " ...	3,991	900	
250	" " ...	4,682	2,500	
261	" " ..	3,349	2,500	
262	" " ...	5,385	3,841	
	Average ...	4,080·3	1,859·3	

GERMAN SUBSTITUTE FOR JUTE.

IMMEDIATELY on the outbreak of the present European War the British Government restricted the export of jute and jute yarns to neutral countries in order to prevent them getting into the hands of the enemies; because the use of jute bags, as a factor in military operations, has grown into familiar history. The blockade had its desired effect and caused an indusrrial defeat in Germany; but the only novel element in this connection is the news that Germany has succeeded in making good the deficiency of raw jute by new devices. Though there has always been some boastfulness in German activities both in the scientific and commercial spheres, yet they have seldom failed to justify it. It would therefore be idle to imagine that Germany would be no longer able to grapple with the difficulties in the present situation. The new German adventure that seemed to threaten the future of our most valued jute industry had exactly the results it was intended to create. In order to mitigate the chances of commercial scare being developed, the Bengal Chamber of Commerce issued a circular explaining the real position and assuring the public that "all is well." Though the crux of the argument in favour of jute seems to be the strong faith in its unalienable position as the cheapest fibre in the world, the new German adventure should not escape our notice. We might therefore examine closely the three kinds of materials said to be used for making sandbags, etc., with a view to definitely determining whether these are makeshifts for the present stringency or are really capable of expansion in the future industrial work.

"This is not indeed the first time that old and waste paper has been suggested as a suitable material for the manufacture of sacking, etc. But the experiments hitherto made have nowhere yielded any satisfactory results. Paper is, in itself, an artificial product that seeks to take the best out of the fibrous materials employed in its manufacture, chiefly with respect to adhesiveness, compressibility, and tearing capacity. The major portion of modern paper is made of wood-pulp and this kind is likely to be the preponderant element in the quantities that may be available for the new treatment. Wood, when crushed by machinery, is resolved into

its constituent fibres that are necessarily short, harsh, and brittle. Even bast, which stands intermediate between wood and true fibre, invariably lacks the elasticity and fineness of the latter. No doubt the recent advances in applied chemical sciences can do much but they have their limitations. And here also the old adage holds equally good as elsewhere. *Ex nihilo nihil fit.* Thus paper, when it undergoes a second pounding before it is reduced into the fluffy condition suitable for spinning, may very probably have the ultimate strands of fibres more broken up than before and would thus be absolutely lacking in tensile strength. The chief characteristics which make jute so suitable lie in its length, fineness, tenacity, and suppleness. This tenacity is due to the fibrous texture and the thickness of its walls; and its elasticity to the length and fineness of the filaments into which it may be sub-divided, but each of which still continues to remain extremely soft and flexible. None of these conditions can the paper fibre be expected to fulfil. A familiar example is in the case of Tussar silk which is capable of great tensile strain. Yet the fibre spun out of the cut cocoons is at no time capable of much resistance.

"Cellulose is also a fibrous material obtained from wood-pulp and is thus cousin-german to paper. It has, however, to undergo no second transformation. But the same disadvantages as quoted against paper would be repeated in this case also. Moreover, the cost, trouble, and the special kind of treatment together with special machinery necessary would render it, under normal conditions, quite useless as a textile fibre in competing with jute.

"The third, *viz.*, willowrose, has been reported as yielding a fibre of good quality and colour and thus deserves serious attention. In the first place it has to be pointed out that the plant used in Germany for its fibre is the hairy willow herb *Epilobium hirsutum.* The willowrose, in a strict sense, is a name given to *Epilobium roseum* which seldom rises to a greater height than two feet. Both these species are widely distributed in Asia and Europe, extending from the temperate regions of the North-Western Himalayas, through Western Asia, to Europe and the British Isles. *Epilobium hirsutum* rises to about five feet in height and is most in evidence in

India in the districts of Bushahr, Kulu, and Kangra, and near Simla. So far there does not exist any record of any of the *Epilobiums* being used for the production of fibre, but in New York and United States of America *E. angustifolium* has sometimes been utilized for its bast fibre. Very probably it is history repeating itself and the German scientists trusting to the theory of signatures while seeking for a jute substitute. The pods of *Epilobium* when on the plant appear to be mere thin edition of the long fruited jute plant—*Corchorus capsularis*. Attempts are now being made to make a complete study of the plant as a possible fibre producer, and it would at this stage be premature to offer any definite opinion on the point. But some facts stand out in significant prominence which have to be taken into account.

" *Epilobium hirsutum* and its other species, like all wild plants, are much branched shrubs that have to be trained into straight thin growths by intensive cultivation. There must be a regular process of this kind of work before Germany could succeed in obtaining even a workable fibre out of the plants. But to merely obtain a fibre capable of being utilized for the manufacture of bags and sacking and to place it in a position contiguous to that of jute are two very different undertakings. In the first place it would never do for Germany to cultivate *Epilobium hirsutum* to any considerable extent in the highly manured agricultural lands of Germany that are devoted to such remunerative and industrial crops as beet, potatoes, and grapes, or food-grains. Moreover, it would require several cycles of culture before good *jats* or races of fibre producers could be evolved out of *Epilobium hirsutum*, and particularly so when it has never been known as specially amenable to good treatment or particularly prolific in the Central European region. Thus the chances of this newly discovered fibre soon proving a menace to jute must be reckoned as extremely remote." (From *Capital*, dated 27th October, 1916.)

We would like to add in this connection that the peculiar conditions now in existence in the territories of the Central Powers render it possible for many " Substitutes " to be manufactured at a profit which could not stand the competition of the outside world for a

day. If one has to have a thing—genuine or substitute—and its cost is immaterial, much can be done in the way of producing it when the limiting factor of most competition, cost, is removed.—[EDITOR.]

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GERMANY'S EXPLOITATION OF NEW MATERIAL.

THE Committee of the Bengal Chamber of Commerce has distributed among its members the following extract from the *Chicago Daily News* of the 1st October, 1916, owing to its importance with respect to the question of jute substitutes :—

" Capital was subscribed last week by the greatest spinners, merchants, and bankers of Germany for the exploitation and manufacture of a new material which, if it meets with expectations, will make Germany independent of the importation of cotton, jute, and wool. It is made from a plant called Typha, a sort of " cat tail " growing in marshes, and can be worked into threads according to the kind of cloth to be made. I have seen samples of the results obtained by the process so far as it has been perfected. There are many varieties of the plant having different fibres which can be worked into coarse jute or the finest cotton substitutes with all the strength and softness of cotton fabrics.

" The crop of Typha this year at the lowest estimate is 500,000 tons while the highest estimate is 6,000,000 tons," continues the extract. " The yield in the finished product is 10 per cent. When sown with this plant, Germany's extensive marshes will offer an absolutely unlimited supply at a small cost, as no good land is needed. The crop can be gathered from June until the hoar frosts set in and several crops can be raised in a year as the plant grows as rapidly as alfalfa. Even in the experimental stages of manufacturing, the cost of the cloth shows a decrease over the normal cost of the goods imported. I have been told by a Berlin merchant, whose name is known throughout the world, that Germany as early as next year will make enough of the material to equal all the supplies usually imported, largely from America and Egypt. The discovery is considered of extraordinary importance and it may make Germany an exporter of this product instead of being an importer

of cotton, wool, and flax. The first work with the new capital will be to develop the coarser grades of material and then, after further experiments, the finer grade." Real results are expected next year.—(*The Pioneer Mail*, Allahabad, dated 20th January, 1917.)

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FIBRE AND FIBRE-PRODUCTION.

In *Bulletin No.* 45 (*New Series*) *of New Zealand Department of Agriculture*, by Hubert J. Boeken, we have an interesting description of fibres and fibre-production in which the author deals entirely with bast and leaf fibre; that is to say jute and flax types.

After a description of the various methods adopted for introduction into different countries and its cultivation and manufacture, he sums up the case for the future in a very convincing way and we quote his words:—

"In the beginning the East African planters fell into the mistake of most new industries—that of wanting to produce large quantities, irrespective of quality; but they soon found out that it paid them better to concentrate their attention on the production of quality fibre, feeling sure that once their men were trained and kept to secure a high standard of quality, quantity would follow as a matter of course. They were helped in this endeavour by the appearance of the Corona fibre-cleaning machine, which enabled them to secure a standard and uniformly good quality without lessening the output. To-day East African fibre commands the best prices in the market, and is sure to keep up this commanding, so long as the planters maintain the present high quality of their hemp.

"The spinners will not be troubled with second-rate hemp while good fibre can be obtained, and there can never be an over-production of good fibre, since there are innumerable uses to which good fibre may be put. For instance, the best selected East African sisal hemp is now used largely in the manufacture of hats, which are sold under the name of 'horsehair hats.' Sisal hemp takes any dye brilliantly.

"There is a great number of other hard-fibre-bearing plants, but up to the present they can hardly be considered of commercial value

but we must look for them for the time when the actual commercial hard fibres become scarce, or too costly to be used by spinners.

"The waste fibres (tow) both of soft and hard fibres make excellent paper, and are greatly in demand as long as their price is somewhat below that of Russian rags—about £12 to £15 a ton.

"I have known the price of sisal hemp to be as low as £11 and as high as £52 a ton, the average price being £20 a ton. The cost of production is about the same as that of New Zealand flax.

"It is an historical fact that whenever the producers of fibre, be it of soft or hard fibre, grow negligent about the quality of their produce the prices fall, and that it takes them a long time afterwards to regain their reputation, and thereby secure anew profitable prices. Quality is the main thing—and a uniform good quality at that—to secure steady prices and a regular eager market. This not only means that the fibre contained in the same bale must be of uniform strength and colour, but it must also be of uniform length. Fibre, no matter to what class it belongs, causes the spinner trouble in the spinning-process, and consequent loss of money, when short and long fibres are indifferently baled together.

"Here in the Dominion, where the flax industry is of such importance to the community, it would be well if the millers, one and all, watched jealously over the quality of the fibre produced. It is the duty of everybody to improve the tone of the New Zealand flax market, and to help in establishing that reliance and confidence which presents the most impregnable fortress to the attacks of competition. If the purchasers of New Zealand flax are assured of getting a steady supply of a uniformly good-quality fibre, that reliance and confidence will be born in them which is half the commercial battle, and it will assure to the flax-miller a regular, steady, and profitable price for his product.

"The New Zealand grading-system is excellent, but one cannot expect the graders to give to flax points which that flax does not deserve, whereby the consumers of New Zealand flax would be led to place as much or as little faith in New Zealand grading-certificates as they do to-day in the manila-hemp market, where the absence of official grading is the cause of constant unpleasantness among

producer, broker, and consumer. It is to the interest of all and every one of the New Zealand flax-millers to strive for quality first, and to maintain it. The quantity will then, with the conscientious training and improved methods of working the flax, come naturally of itself."

It must be obvious to all how important the subject is with which he deals, and here in India where adulteration is the cause of so much trouble and militates against the axiom of a good price for a good thing, the question of quality is all important both to obtain and to maintain.—[WYNNE SAYER.]

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PUSA DAIRY HERD.

THE following photographs (Plates XIII—XVII) illustrate the buildings and some of the cattle of the Pusa Dairy Herd. The herd at present consists of over 100 cows, 10 bulls, and nearly 200 young stock. Though for convenience all the animals are kept together there are two distinct herds:

I. Pure Montgomery.
II. Cross-bred Ayrshire-Montgomery.

I. *Pure Montgomery herd.* As there are now 3-4 generations of the pure herd, of which careful milk records have been kept, the herd may now be said to be really pedigree. There are some excellent strains in the herd, some of the animals have gone over the 7,000 lb. mark in one lactation period (including milk taken by calf). No new blood has been introduced lately and a certain amount of inbreeding is being carried out to intensify the milk strains. Not much weight is put on points and colours, the milk pail is the chief arbiter. A standard, for inclusion in the herd, of 4,000 lb. milk in one lactation period, is the minimum production aimed at.

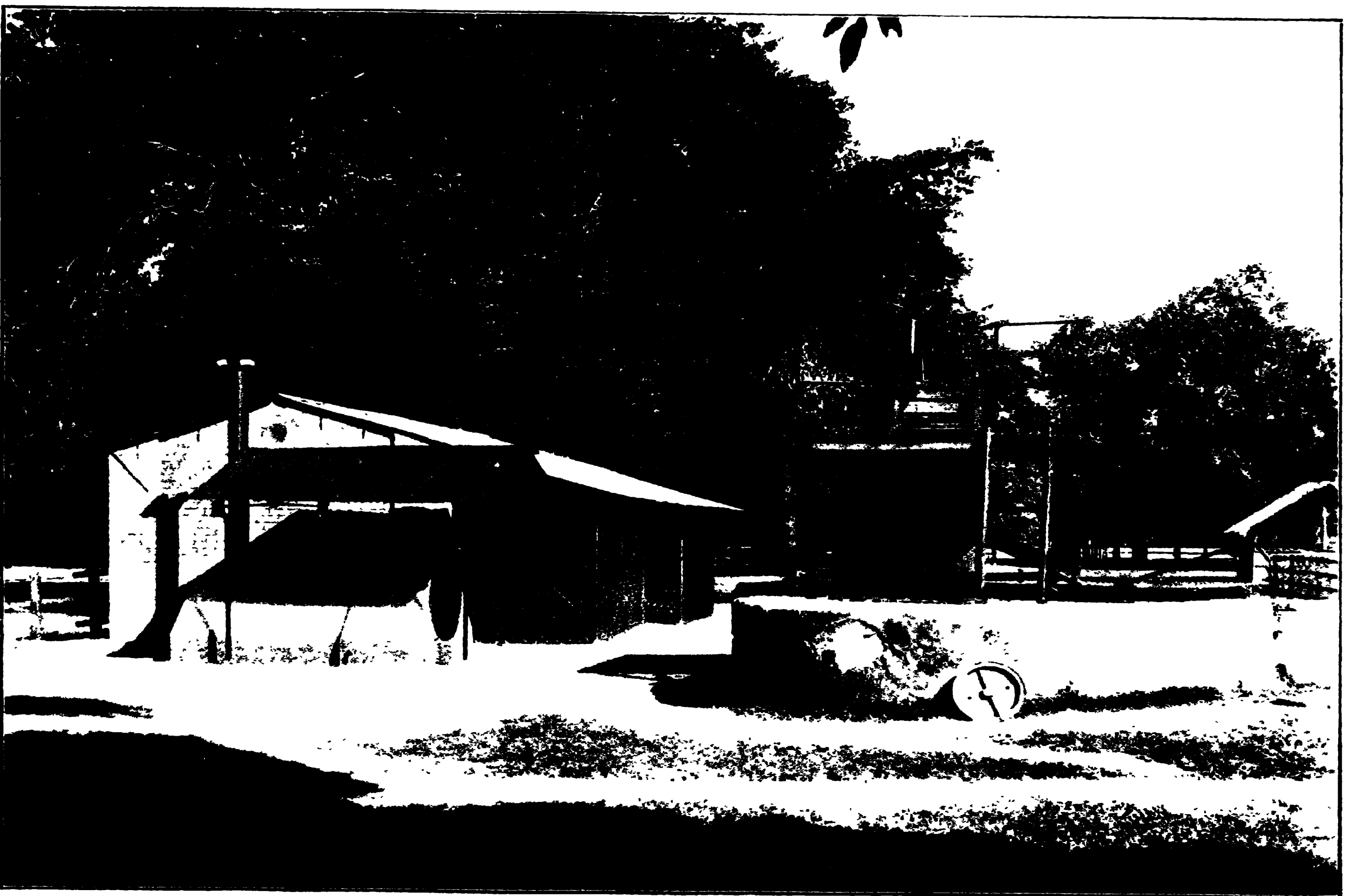
II. *Cross-bred Ayrshire-Montgomery herd.* Work in this direction has only been carried out for three years, so no experience of the milking capacity of the crosses has been obtained. The cross-bred cows will be crossed with the cross-bred bulls and the results should be of the greatest importance. It is expected that not only will the milk production be increased but also that the



TARA MILK CATTLE LINES.



INTERIOR OF MILKING SHED.



DAIRY SHED AND WASH HOUSE.



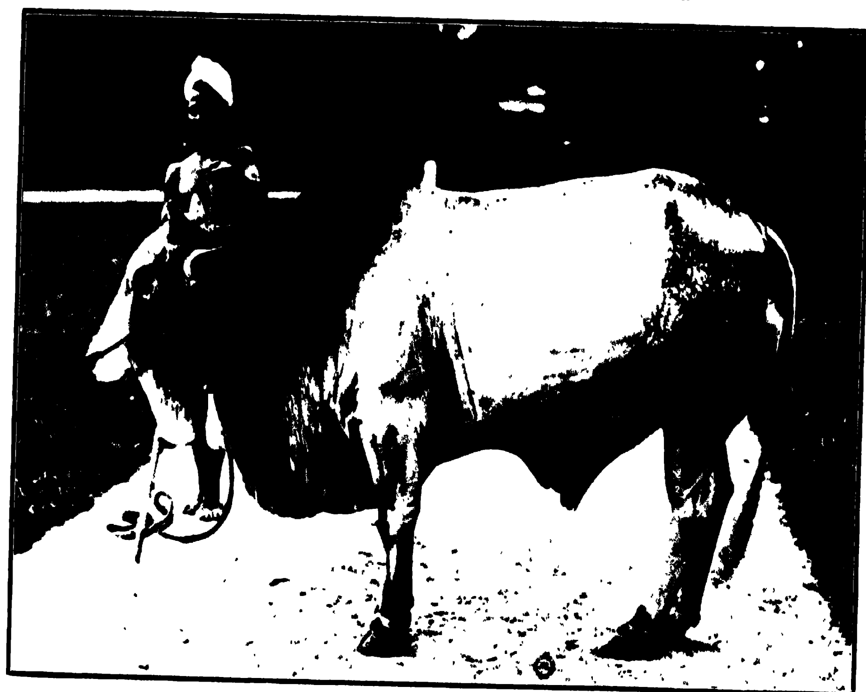
AYRSHIRE BULL "LESSNESSOCK WILDFIRE."



STUD BULL.



CARSTON ROYAL SCOTCH AYRSHIRE BULL.



STUD BULL.



YOUNG CROSS-BRED AYRSHIRE MONTGOMERY CATTLE.



TYPICAL MONTGOMERY COW.

cross-bred cows will calve more regularly and that it will be possible to wean the calves.—[G. S. HENDERSON.]

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THE NADIAD AGRICULTURAL ASSOCIATION.

THIS Association was granted in 1886 a plot of land near Nadiad for experimental purposes, free of assessment, but as the Government farm at Nadiad was opened in 1904, it ceased its operations on this land and leased it out, contributing the rent to the funds of the Government farm. Since last year the Government farm at Nadiad has been converted from a tobacco farm to a fodder farm, and the Agricultural Association being anxious to resume operations of a more general nature on its own plot applied for certain concessions. In view of the past work of the Association and the considerable contributions that they have made towards agricultural improvements, the Government of Bombay have sanctioned the retention by the Association of the plot (worth about Rs. 12,175) as a revenue-free holding with a view to enabling them to do experimental work. In addition, the Association will also have the services of one District Overseer placed at their disposal to supervise the work and to assist them in other ways from time to time. The Association's plot will serve as a seed and improvement depôt. It will demonstrate the value of castor cake as a supplementary dressing for tobacco, and will continue the demonstration formerly made on the Nadiad farm of the best kind of cotton for the locality. It will also demonstrate the value of ensilage; multiply a strain of white seeded *tur* which was isolated on the Nadiad farm, and test varieties of sugarcane and methods of cultivating it. We hope this will serve as an example to other agricultural associations which might easily increase their activities and thus become helpful in spreading agricultural improvements.—[EDITOR.]

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THE WORLD'S CEREAL CROPS.

THE International Institute of Agriculture, Rome, has just published its half-yearly "Statistical Notes on Cereals," which throws light on the situation from the point of view of yield, trade, and

consumption of the world's cereal crops, together with the prices and rates of ocean freight. The publication is based on official information furnished by the countries adhering to the Institute, and deals with wheat, rye, barley, oats, and maize. These statistical notes pass in review successively the components of the food problems in general: yield, remainders from previous harvests, and consumption. The position as regards the northern hemisphere crops is proved by the following data :—

1916 crop—

Of wheat	= 80·2 per cent of 1915 crop	and	94·9 per cent of average crop		
Of rye	= 98·3 per cent	,,	,,	103·9 per cent	,, ,,
Of barley, oats, and maize ...	=91·2 per cent	,,	,,	101·2 per cent	,, ,,

The smallness of the wheat crop is chiefly due to the failure of the crops in parts of Canada and the United States, but it must be added that 1915 yields were exceptionally abundant. The second element in the problem concerns the remainders from the previous year, and these are, fortunately, of some importance, coming in as they do to meet the deficiencies of the present season. To these remainders should be added the crops to be reaped in the southern hemisphere in December and January. It is clear that no one can estimate with any precision what may be the actual consumption of the world from now until the next harvest. But a basis is provided by taking into account the average consumption for a series of years, and forming estimates accordingly. The Statistical Notes of the Institute in Rome draw attention to several factors tending to diminish or augment consumption. Among the first of these may be cited the decline in yield, high prices for grain or for other foodstuffs, the general economic situation, the reduced manufacture of certain articles, and especially those in breweries and distilleries, the depopulation of invaded territories, the displacements of troops, the various legislative enactments, etc. On the other hand, certain factors may tend to augment consumption, such as abundant crops, improvement in economic situation, the flow of population from invaded territories, the arrival of foreign armies or of prisoners of war, the needs of mobilized units in excess of their

normal requirements, waste. It is thus obvious that considerable drafts upon the remainders mentioned must be made in order to bridge over the interval between the two harvests, and serious economies in consumption are both necessary and urgent. Otherwise available supplies at the end of the current season will be much reduced, and may even be insufficient if next harvest should not prove to be a plentiful one. The Crop Reporters of the Board of Agriculture, in reporting on the crops and the agricultural conditions in England and Wales on December 1st, state that the weather of November was wet nearly everywhere, and comparatively little progress could be made with autumn work, so that the backward condition of farming noted last month was, on the whole, accentuated. Of the total area intended for wheat, barely three-fifths have as yet been sown, though more progress appears to have been made in the important counties of Lincoln and Norfolk than elsewhere. As compared with December 1st last year, the area actually seeded by this date would appear to be nearly 15 per cent smaller, though here also the same counties are in advance of most of the country. Only that sown early or on light land is yet showing above ground, but it is looking well.—(*The Economist*, London, December 16, 1916.)

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THE RAIPUR DIVISIONAL SHOW AND CONFERENCE.

A MOST successful Divisional Agricultural Show and Conference was held on the Raipur Experimental Farm in the Chhattisgarh Division in the Central Provinces on the 1st and 2nd December last. It was attended by the Hon'ble the Chief Commissioner Sir Benjamin and Lady Robertson and many of the officials of the Revenue Department of the Division.

The Show consisted of two parts: (1) A Cattle Show, and (2) a Show for Agricultural Produce, including Fruit, Flowers, Vegetables, Tussar Silk, etc. Nearly 600 cattle were exhibited. Most of these were of the small but hardy Chhattisgarh breed which has deteriorated owing to centuries of partial starvation in the plains of this district where their staple food is one of the poorest

grasses (*i.e.*, Spear or *Sukla* grass). It will take centuries of careful feeding and selection to raise this dwarfed breed to its original size again. The Department of Agriculture is trying to improve the breed by establishing cattle-breeding farms.

The samples of groundnut, wheat, rice, *gur*, cotton, and sugarcane sent in were very good. Most of them were of improved varieties the seed of which was distributed by the Department through its Experimental and Seed Farms. Many of the rice samples were of *Gurmatia*, a late but heavy yielding paddy, of which variety the Department distributed 337,496 lb. of seed this year. Many of the canes exhibited were of giant dimensions—standing 16 feet in height in some cases. They were mostly exotic varieties introduced by the Department in this Division within the last few years. The beautiful samples of cottons seemed at first sight out of place in a Show in this Division which is a rice tract with a heavy annual rainfall of 50″ to 60″. The rainfall of the cotton tract ranges from 30″ to 44″ per annum and very little cotton is grown outside this belt. But in the Feudatory States of Chhattisgarh there are small tracts protected by the hills where the rainfall seldom exceeds the limit for cotton and a few thousand acres of this staple are still grown in such parts. The Department has proved, moreover, that when grown on light *bhata* soil with an open well-drained and therefore well-aerated soil, a heavy rainfall is not detrimental to the growth even of cotton, and its cultivation has therefore been started on the *bhata* soil of the Government Farm at Chandkhuri. It has been grown there so successfully that when given irrigation and manure, yields of 2,000 lb. *kapas* per acre could be obtained on *bhata* light soils.

For centuries hundreds of thousands of acres of this light soil have been fallow and produced nothing but the poorest spear grass. With the advent of irrigation facilities, consequent on the completion of some of the large irrigation works, such areas undoubtedly offer great possibilities for the cultivation not only of cotton but of groundnut, cane, and fodder crops.

Strange-looking roots—the staple food of the jungly tribes of Bastar State and also samples of Tussar silk sent in by other States



A pair of full-grown Chhattisgarhi Bullocks.



Improved Ploughs at work in the Show Grounds.



New canes introduced by the Department and exhibited by the Growers.



Visitors at the Show from Bustar State.

RAIPUR DIVISIONAL SHOW AND CONFERENCE.

attracted much attention. For the best silk exhibit a large silver cup to be called the Lady Robertson Cup was presented by the Hon'ble Mr. Nathmal.

In the Demonstration Yard attached to the Show the Department demonstrated the working of ploughs, winnowers, cane mills, fodder-cutters, the shuttle handloom, and other improved labour-saving contrivances. A striking feature of the gathering was that Rajas and *zamindars*, dressed in their golden colours, mingled with quaint jungle folk from the wilds of Bastar whose principal garment consisted of a kind of tippet made of strips of brown fibre obtained from some jungly species of plant.

On December 2nd a Divisional Conference attended by nearly 2,000 people was held to discuss the agricultural improvements being carried out in the Division. At the close of the discussion the prizes, *sanads*, and medals were given out. Thus ended the most successful agricultural gathering ever held in Chhattisgarh which will long be remembered in this Division as a red-letter day in the annals of agricultural development.—[D. CLOUSTON.]

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WATER HYACINTH.

THE water hyacinth, botanically known as *Eichornia crassipes*, has become a very serious pest in parts of India, particularly Burma and Bengal. In the former province the pest is so widespread that it has been found necessary to legislate against it and the Burma Water Hyacinth Act, No. I, 1917, has been passed in the local Legislative Council. The Act is as follows :—

THE BURMA WATER HYACINTH ACT I, 1917.

An Act to eradicate the Plant known as the Water Hyacinth.

Whereas it is expedient to make provision for the eradication from Burma of the plant known as the water hyacinth ; It is hereby enacted as follows :—

Preamble.

Short title and extent.

1. (*1*) This Act may be called the Burma Water Hyacinth Act, 1917.

(*2*) It extends to the whole of Burma.

Definition.

2. In this Act the expression "water hyacinth" means the plant botanically known as *Eichornia crassipes*, and includes the seed and every part of the plant.

Water hyacinth declared a public nuisance.

3. The presence of the water hyacinth in Burma is hereby declared to be and is a public nuisance.

Prohibition of possession of water hyacinth.

4. No person shall possess or keep the water hyacinth, and every owner or occupier shall destroy any water hyacinth growing in or on any place belonging to or occupied by him in accordance with the rules made under this Act.

Power to issue notice and enter upon land to destroy water hyacinth.

5. (*1*) Any person duly authorised in that behalf by a Government Officer not below the rank of a Township Officer may serve such notice as may be prescribed by any rule made under this Act on the owner or occupier of any place to destroy the water hyacinth growing thereon, in accordance with the terms of such notice.

Contravention of terms of notice.

(*2*) If any owner or occupier on whom notice under this section has been duly served fails to comply therewith, such person may enter upon such place and take all the measures necessary for the destruction ot the water hyacinth without being liable for trespass or tor any injury to crops, pasture, or fishery rights in so doing, and the costs of taking such measures or such portion thereof as may be sanctioned by the Deputy Commissioner shall be borne by the said owner or occupier and shall be recoverable as if they were arrears of land revenue.

Penalties.

6. Any person who—

(*1*) possesses or keeps the water hyacinth; or

(*2*) fails to destroy in accordance with the terms of the notice referred to in section 5 any water hyacinth which may be found growing in any such place as aforesaid—

shall be guilty of an offence, and shall be liable on conviction thereof to a fine not exceeding one hundred rupees, or upon a second or subsequent conviction to a fine not exceeding Rs. 500.

7. (*1*) The Local Government may make rules for the purpose of carrying out the provisions of this Act.

Power to make rules.

(*2*) In particular and without prejudice to the generality of the foregoing provisions the Local Government may make rules—

(*a*) prescribing the methods by which and the time within which the destruction of the water hyacinth shall be completed;

(*b*) prescribing the form and the terms of a notice under section 5.

8. The Local Government may, with the previous sanction of the Governor-General in Council, by notification, apply all or any of the provisions of this Act to any weed or plant which in its opinion is noxious and to the seed or any part of such weed or plant, and thereupon such provisions shall apply, *mutatis mutandis*, to such weed or plant.—[EDITOR.]

Power to extend provisions to other noxious weeds or plants.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

MYCOLOGICAL AND ENTOMOLOGICAL CONFERENCE. In accordance with the proposal of the Government of India to adopt the policy of Sectional meetings in years in which a full meeting of the Board of Agriculture is not held a conference of mycologists and entomologists sat at Pusa from the 5th to the 9th February, 1917. The session was a great success and was attended by representatives of nearly all provinces and the officers of the Indian Tea Association.

The first day's proceedings were opened by Mr. J. MacKenna, M.A., I.C.S., Agricultural Adviser to the Government of India, who welcomed the representatives from the different provinces. After some questions of general policy had been discussed in full session, the conference broke up into two sections, *viz.*, mycological and entomological, for the discussion of special subjects. The proceedings will be published in due course and a fuller account given in a later issue of the Journal.

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HIS HONOUR SIR EDWARD GAIT, K.C.S.I., C.I.E., I.C.S., Lieutenant-Governor of Bihar and Orissa, paid a visit to Pusa on the 7th February, 1917, from Muzaffarpur.

His Honour inspected the Botanical area and afterwards went over the Farm and estate. Much interest was displayed in the cattle and the working of the steam tackle. In the afternoon His Honour visited the different Sections of the Institute and the Silk House.

After tea His Honour and party left for Muzaffarpur by motor at 5 P. M.

A PARTY of 25 members of the Bihar Planters' Association paid a very successful two days' visit to Pusa on the 15th and 16th February, 1917. They were accommodated and entertained by the Staff of the Institute.

On the 15th February they visited the Botanical area in the morning, and in the afternoon went over the Indigo Research Chemist's Section in the Institute where they saw the work in progress in connection with indigo paste manufacture. In the evening Mr. C. M. Hutchinson, B.A., Imperial Agricultural Bacteriologist, delivered a lecture on "Soil Bacteria and Fertility" which was illustrated by magic lantern slides, and listened to with great interest.

Next day they visited the Farm and spent the morning going over the crops and cultivation and seeing the cattle. The rest of the day was spent in visiting the other Sections. The visit was greatly appreciated by all concerned, and it is hoped that it will become an annual event.

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THOUGH somewhat belated we offer our hearty congratulations to—

(1) The HON'BLE SIR CLAUDE HILL, K.C.S.I., C.I.E., I.C.S., on whom His Imperial Majesty the King-Emperor of India has been graciously pleased to confer the honour of a Knight Commander of the Order of the Star of India;

(2) LIEUTENANT-COLONEL JOHN FARMER, F.R.C.V.S., Civil Veterinary Department, Chief Superintendent, Punjab, who has been admitted a Companion of the Indian Empire; and

(3) DR. HAROLD H. MANN, D.Sc., M.Sc., F.I.C., Principal, Agricultural College, Poona, and Agricultural Chemist, Bombay, who has been awarded the Kaiser-i-Hind Medal of the First Class for public service in India.

MR. J. H. BARNES, B.Sc., F.I.C., F.C.S., Agricultural Chemist and Principal, Punjab Agricultural College, Lyallpur, has been appointed as Imperial Agricultural Chemist in the Agricultural Research Institute, Pusa. He joined his new post on the 1st March, 1917. He is being succeeded as Principal of the College by Mr. W. Roberts, B. Sc., Professor of Agriculture.

THE University of Bombay has conferred the degree of M.Sc., (in Botany) with distinction on Mr. J. F. Dastur, First Assistant to the Imperial Mycologist, Pusa.

Reviews.

Natural Orders in Botany.—BY ETHELBERT BLATTER, S.J., F.L.S., Professor of Botany in St. Xavier's College, Bombay. Second Edition. Price R. 1. Published at St. Xavier's College, Bombay, 1916.

THIS book is a welcome addition to the number of scientific text-books written in India for Indian students. Up to now, especially in Botany, Indian students have been perforce dependent on text-books written in Europe for European conditions, and the results have in some cases been both ludicrous and useless. Father Blatter, a widely travelled botanist of considerable attainments, in touch with the most advanced ideas in plant classification, has concentrated in this small volume a great mass of valuable material. The book will be found useful all over India to students of Botany, Agriculture, Forestry, and Medicine. The lover of plants, who cares to learn the easily acquired technical vocabulary, will also find much help here.

What differentiates the book from the general run of such works is the original information given in the *Remarks* which follow the formal description of each notable plant. In these *Remarks* are given interesting facts regarding plant physiology and floral mechanisms, and a host of details not usually available.

A well arranged index completes the book.—[W. B.]

Notes on the History, Uses, and Cultivation of the Papaya.—By H. J. DAVIES, F.R.S.A., F.R.H.S., Superintendent, Government Gardens, Lucknow. Bulletin No. 37, Agricultural Series of the Department of Land Records and Agriculture, United Provinces. Price 1 anna.

THIS is one of the interesting Bulletins recently issued on fruit culture by the United Provinces Department of Agriculture. In addition to the habit and structure of the Papaya plant it deals with medicinal and other properties of the fruit. Though the cultivation of the Papaya is simple and easy, some hints given by the author about planting, grafting, the treatment of cuttings, and selection of varieties will probably prove of use to those interested in the Papaya cultivation.—[EDITOR.]

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Green Manures and Manuring in the Tropics* is the title of a translation, by F. W. FLATTELY of the Department of Zoology, University College of Wales, of a work on tropical Leguminosæ—by P. DE SORNAY, some time Assistant Director of the *Station Agronomique* of Mauritius.

THE title of the original work, "Les Plantes Tropicales Alimentaires et Industrielles de la Famille des Légumineuses," is more appropriate.

M. P. Boname, the Director of the *Station Agronomique*, to whose work frequent reference is made, contributes a Preface, and M. H. Pellet an Introduction in which the scheme of the work is well summarized as follows :—

"An account of the theories on the fixation of nitrogen from the air by the Leguminosæ :—

Value of restorative food and fodder plants, origin, description, cultivation, varieties, yield, uses of numerous species : pea-nut, Bambarra ground-nut, jack bean, pigeon-pea, chick pea, clover, yam bean, lentil, sulla, Bengal bean, etc.

Comparison between various rotation peas.

* John Bale, Sons, and Danielsson, Ltd. London : Price 16s.

Investigation of the manganese, prussic acid, and starch in the Leguminosæ.

Value of Leguminosæ from an agricultural point of view; their use as animal fodder and in pasture.

Plants yielding rubber and resin: Leguminosæ producing tanning matters, dyes, building timber, drugs, textile materials, etc. Leguminosæ as ornamental plants.

Pests attacking the Leguminosæ.

Bibliography.

Seventy-five to eighty hitherto unpublished plates of sketches and photographs lend additional interest to M. de Sornay's work."

The leguminous plants of agricultural value in the tropics are dealt with by M. de Sornay in detail, analyses of the stems, leaves, husks, and seeds with the yields per acre are given in each case, and the analyses are tabulated at the end of the book which is completed by an excellent index.

While the data given are derived chiefly from experience in Mauritius they give a good general idea of the possible economic value of a large number of tropical leguminous plants some of which will probably be new to many agriculturists. To such Mr. Flattely's translation will be a useful book of reference, and there is the more reason on this account to regret the somewhat misleading title, which is likely to prejudice the book in the eyes of those who are working under conditions in which the ploughing in of any cultivated crop is almost out of the question.

One of the most useful purposes that the book is likely to serve, is, in fact, to bring to the notice of tropical agriculturists the large number of leguminous plants which can be turned to direct account, thus enabling fodder and food crops to be substituted for those now grown only as green manures. In this connection it may be noted that the Florida beggar-weed (*Desmodium tortuosum*), the reputation of which is based chiefly on its value as a green manure, is said to yield a useful fodder. On the other hand, the statement that sunn hemp (*Crotalaria juncea*) is not relished by animals is certainly not true of the plant in its young state, when it provides a large bulk of excellent fodder at a very early period in the rainy season.

The figures for yield in the book should be used with caution, as there are many inconsistencies, apparently due to confusion of weights and measures in translation. But these are trifling blemishes that do not in any way diminish the debt owed by British Tropical Agriculture to the translator who has rendered M. de Sornay's valuable work more readily accessible.—[A. C. D.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

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1. A Composite American Text-Book of Geology: *A Text-book of Geology*, by Prof. L. V. Pirsson and Prof. C. Schuchert. Part I, *Physical Geology*, by Prof. L. V. Pirsson. Pp. vii + 444. Price 10*s*. net. Part II, *Historical Geology*, by Prof. C. Schuchert. Pp. vi + 405—1026. Price 12*s*. net. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1915.)
2. Agricultural Geology, by R. H. Rastall, M.A., late Fellow of Christ's College and Demonstrator of Geology in the University of Cambridge. With 51 illustrations. Demy 8vo. Price 10*s*. 6*d*. net. Cambridge Geological Series.
3. Geology, by T. C. Chamberlain and R. D. Salisbury, Heads of the Department of Geography and Geology, University of Chicago. Three volumes (sold separately). Illustrated. Price 21*s*. net each.
4. Chemistry for Rural Schools, by E. Jones and J. J. Griffith. Pp. 184. (London: Blackie & Son, Ltd.) Price 2*s*. 6*d*. net.
5. Chemical Constitution and Physiological Action, by Dr. Leopold Spiegel. Translated by C. Luedcking and A. C. Boylston. Crown 8vo. Price 5*s*. net.
6. Practical Agricultural Chemistry, by S. J. M. Auld, D.SC. (Lond.), PH.D. (Würzburg), Professor of Agricultural Chemistry at University College, Reading, and D. R. Edwardes-Ker, B.A. (Oxon.), B.SC. (Lond.), Head of the Chemical Department, South-Eastern Agricultural College (University of London), Wye, Kent. Illustrated. Price 5*s*. net.

7. Subtropical Vegetable-Gardening, by P. H. Rolfs. Pp. xviii + 309. (New York : The Macmillan Co. ; London : Macmillan & Co., Ltd., 1916.) Price 6*s*. 6*d*. net.
8. The Mechanism of Mendelian Heredity, by T. H. Morgan, A. H. Sturtevant, H. J. Muller, C. B. Bridges. Demy 8vo. Price 12*s*. net. Diagrams.
9. The Principles of Plant Culture: A Text-book for Beginners in Agriculture and Horticulture, by the late E. S. Goff. Revised by J. G. Moore and L. R. Jones. Eighth edition. Pp. xxiii + 295. (New York : The Macmillan Co. ; London : Macmillan & Co., Ltd., 1916.) Price 5*s*. 6*d*. net.
10. Economic Zoology and Entomology, by Vernon L. Kellogg and C. W. Doane. Crown 8vo. Price 6*s*. 6*d*. net.
11. Insect Enemies, by C. A. Ealand. Pp. 223 + plates. (London : Grant Richards, Ltd.) Price 6*s*. net.
12. Surveying and Field Work : A New Volume in " The Glasgow Text-books of Civil Engineering," by James Williamson, M.INST.C.E. Demy 8vo. 360 pages. 293 Illustrations. Price 7*s*. 6*d*. net.
13. Field and Laboratory Studies of Soils: An Elementary Manual for Students of Agriculture, by Prof. A. G. McCall. Pp. viii + 77. (New York: John Wiley & Sons, Inc.; London : Champan & Hall, Ltd., 1915.) Price 2*s*. 6*d*. net.
14. Discovery ; or, The Spirit and Service of Science, by Prof. R. A. Gregory. With 8 Plates. Crown 8vo. Price 5*s*. net.
15. The Principles of Agronomy : A Text-book of Crop Production for High Schools and Short Courses in Agricultural Colleges, by Prof. F. S. Harris and G. Stewart. Pp. xvi + 451. (New York : The Macmillan Co. ; London : Macmillan & Co., Ltd., 1915.) Price 6*s*. net.
16. The Marketing of Farm Products, by Prof. L. D. H. Weld. Pp. xiv + 483. (New York : The Macmillan Co. ; London : Macmillan & Co., Ltd., 1916.) Price 6*s*. 6*d*. net.
17. Growth in Length : Embryological Essays, by Richard Assheton, M.A., Sc.D., F.R.S. With 42 Illustrations. Demy 8vo. Price 2*s*. 6*d*. net.

18. The Principles of Feeding Farm Animals, by Sleeter Bull, Associate in Animal Nutrition, College of Agriculture, and Agricultural Experiment Station of the University of Illinois. 7½″ × 5¼″. Pp. xix + 397. (The Macmillan Co.) Price 7*s*. 6*d*. net.
19. Reclaiming the Waste: Britain's Most Urgent Problem, by P. Anderson Graham. 7½″ × 5″. Pp. xiii + 175. (The Increased Productivity Series.) Country Life. Price 1*s*. net.
20. A Practical Guide to Coco-nut Planting, by R. W. Munro and L. C. Brown, late Government Inspector of Coco-nut Plantations, F.M.S. 7½″ × 5″. Pp. xx + 186. (Ball, Sons, and Danielssohn.) Price 7*s*. 6*d*. net.
21. The Co-operative Movement in India, by Punchanandas Mukhopadhyay, M.A., F.R.E.S. (Lond.), Professor of Economics, Presidency College, Calcutta, and Assistant Editor, Bengal Co-operative Journal. Second Edition. Price Rs. 4-8.
22. The Law and Principles of Co-operation in India, by H. Calvert, I.C.S., Registrar, Co-operative Societies, Lahore. Nearly ready. Royal 8vo, cloth. Price about Rs. 6. Orders being registered.
23. Co-operation: Comparative Studies and the Central Provinces System, by H. R. Crosthwaite. Royal 8vo, cloth. Price Rs. 6. *This book will be reviewed in a later issue of the Journal.*
24. Modern Dairy Farming (Bazaar, Exchange, and Mart), by Professor James Long. 7¼″ × 5″. Pp. 131. Price 1*s*. net.
25. World Commerce in its Relation to the British Empire, by Norman R. Byers. With an Introduction by W. R. Lawson. 7¼″ × 4¾″. Pp. 104. (P. S. King.) Price 1*s*. net.
26. The Foundations of Indian Economics, by Radhikamal Mukerji, Professor of Economics, Krishnath College, Berhampore, Bengal. With an Introduction by Patrick Geddes. 9″ × 6″. Pp. xxvii + 515. (Longmans.) Price 9*s*. net.
27. The Weather-Map: An Introduction to Modern Meteorology. By Sir Napier Shaw. Pp. 94. (London: Meteorological Office, Exhibition Road, S. W., 1916.) Price 4*d*.

28. Catalogue of Scientific Papers. Fourth Series (1884—1900). Compiled by the Royal Society of London, Vol. XV, Fitting-Hyslop. Pp. vi + 1012. (Cambridge: At the University Press, 1916.) Price £2 10*s*. net.

29. A Text-Book of Botany for Colleges. By Dr. W. F. Ganong. Pp. xi + 401. (New York: The Macmillan Co.; London: Macmillan & Co., Ltd.) Price 8*s*. 6*d*. net.

30. What is Instinct? By C. B. Newland. Pp. xv + 217. (London: John Murray.) Price 6*s*. net.

31. The High Price of Sugar and How to Reduce It. By H. H. Smith. Pp. iv + 54 (London: John Bale, Ltd.) Price 1*s*. net.

32. Fertilizers. By the late Dr. E. B. Voorhees. Revised edition by J. H. Voorhees. Pp. xv + 365. (New York: The Macmillan Co.; London: Macmillan & Co., Ltd.). Price 6*s*. 6*d*. net.

33. The Fauna of British India, including Ceylon and Burma. Coleoptera, Rhynchophora, Curculionidæ. By Dr. G. R. K. Marshall. Pp. xv + 367. (London: Taylor and Francis.) Price 15*s*.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs.

1. The Gases of Swamp Rice Soils, Part IV. The Source of the Gaseous Soil Nitrogen. By W. H. Harrison, D.Sc.; and P. A. Subramania Aiyer, B.A. Chemical Series, Vol. V, No. 1. Price Rs. 2, or 3*s*. 6*d*.

2. Observations on the Inheritance of Anthocyan Pigment in Paddy Varieties. By G. P. Hector, M.A., B.Sc. Botanical Series, Vol. VIII, No. 2. Price R. 1, or 1*s*. 6*d*.

3. Pollination and Cross-fertilization in the *Juar* Plant. By R. J. D. Graham, M.A., B.Sc. Botanical Series, Vol. VIII, No. 4. Price R. 1, or 1*s*. 6*d*.

4. *Phytophthora* Sp. on *Heavea Brasiliensis*. By J. F. Dastur, B.Sc. Botanical Series, Vol. VIII, No. 5. Price As. 12, or 1*s*.

5. *Phytophthora* on *Vinca rosea*. By J. F. Dastur, B.Sc. Botanical Series, Vol. VIII, No. 6. Price As. 8 or 9*d*.
6. The Dissemination of Parasitic Fungi and International Legislation. By E. J. Butler, M.B., F.L.S. Botanical Series, Vol. IX, No. 1. Price Re. 1-4 or 2*s*.

Bulletins.

1. Rinderpest—Preparation of Anti-serum. By A. W. Shilston, M.R.C.V.S. Pusa Bulletin No. 64. Price As. 3 or 4*d*.
2. Saltpetre: Its Origin and Extraction in India. By C. M. Hutchinson, B.A. Pusa Bulletin No. 68. Price As. 4 or 5*d*.

Report.

1. Report on the Progress of Agriculture in India for 1915-16. Price As. 10 or 1*s*.

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1st AUGUST, 1916, TO 31st JANUARY, 1917.

No.	Title	Author	Where published
	GENERAL AGRICULTURE		
1	The *Agricultural Journal of India*, Vol. XI, Parts III & IV, and Vol. XII, Part I. Price Rs. 2; annual subscription Rs. 6.	Issued from the Agricultural Research Institute, Pusa.	Messrs. Thacker, Spink & Co., Calcutta.
2	Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist), for 1915-16. Price As. 6 or 7*d*.	Ditto	Government Printing, India, Calcutta.
3	Report on the Progress of Agriculture in India for 1915-16. Price As. 10 or 1*s*.	Agricultural Adviser to the Government of India, Pusa.	Ditto.
4	Berseem as a new fodder crop for India. Bulletin No. 66 of the Pusa Agricultural Research Institute. Price As. 3 or 4*d*	G. S. Henderson, N.D.A., N.D.D., Offg. Imperial Agriculturist.	Ditto.
5	Third Report on the Improvement of Indigo in Bihar. Bulletin No. 67 of the Pusa Agricultural Research Institute. Price As. 4 or 5*d*.	Albert Howard, C.I.E., M.A., Imperial Economic Botanist, and Gabrielle L. C. Howard, M.A., Second Imperial Economic Botanist.	Ditto
6	Guide to Agricultural Section, Pusa.	Issued from the Agricultural Research Institute, Pusa.	Ditto.
7	Annual Report of the Department of Agriculture, Bengal, for the year ending 30th June, 1916. Price As. 7 or 8*d*.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depôt, Calcutta.
8	Annual Reports of Expert Officers of the Department of Agriculture, Bengal, for the year ending 30th June, 1916. Price R. 1-4 or 1*s*. 10*d*.	Ditto	Ditto.
9	*Krishi Samachar* or Year Book of the Department of Agriculture, Bengal (in Bengali) for the year 1321 B. S. Price As. 12.	Ditto ...	Ditto.
10	Annual Report of the Department of Agriculture, Bihar and Orissa, for the year ending 30th June, 1916. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Bihar and Orissa.	Bihar and Orissa Government Press, Patna.
11	Report on the Agricultural Activities of Government in Bihar and Orissa for the year ending 30th June, 1916. Price R. 1 or 1*s*. 6*d*.	Ditto	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		General Agriculture—contd.	
12	Report on the Wage Census of Bihar and Orissa taken in April 1916.	Issued by the Department of Agriculture, Bihar and Orissa.	Bihar and Orissa Government Press, Patna.
13	Leaflet on the Groundnut plant: its cultivation and uses.	Ditto ...	Ditto.
14	Report on the Administration of the Agricultural Department of the United Provinces of Agra and Oudh for the year ending 30th June, 1916. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
15	Season and Crop Report of the United Provinces of Agra and Oudh for 1915-16. Price As. 8 or 9*d*.	Ditto ..	Ditto.
16	Report on the Agricultural Stations of the Western Circle, United Provinces of Agra and Oudh for the year ending 30th June, 1916. Price As. 8 or 9*d*.	Ditto ...	Ditto.
17	Report on the Cawnpur Agricultural Station for the year ending 30th June, 1916. Price R. 1 or 1*s*. 6*d*.	Ditto .	Ditto.
18	Report on the Partabgarh Agricultural Station for the year ending 30th June, 1916. Price As. 8 or 9*d*.	Ditto ...	Ditto.
19	Report on the Atarra Agricultural Station for the year ending 30th June, 1916. Price As. 6 or 6*d*.	Ditto ...	Ditto.
20	Report on the Benares Agricultural Station for the year ending 30th June, 1916. Price As. 6 or 6*d*.	Ditto ...	Ditto.
21	Annual Report of the Kumaun Government Gardens for 1915-16. Price As. 8 or 9*d*.	Issued by the Commissioner, Kumaun Division.	Ditto.
22	Hints for the cultivation of Roses. Bulletin No. 36 of the United Provinces Department of Agriculture. Price 1 anna.	H. J. Davies, F.R.H.S., Superintendent, Government Horticultural Gardens, Lucknow.	Ditto.
23	Notes on the History, Uses, and Cultivation of the Papaya. Bulletin No. 37 of the United Provinces Department of Agriculture. Price 1 anna.	Ditto ...	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
24	Notes on Oranges and Lemons. Bulletin No. 38 of the United Provinces Department of Agriculture. Price 1 anna 6 pies.	H. J. Davies F. R. H. S., Superintendent, Government Horticultural Gardens, Lucknow.	Government Press, United Provinces, Allahabad.
25	Notes on Lawns. Bulletin No. 39 of the United Provinces Department of Agriculture. Price 1 anna.	Ditto ...	Ditto.
26	Annual Report of the Department of Agriculture, Punjab, for the year ending 30th June, 1916. Price As. 12 or 1*s*.	Issued by the Department of Agriculture, Punjab.	Government Printing Punjab, Lahore.
27	Season and Crop Report of the Punjab for the year 1915-16. Price As. 12 or 1*s*.	Ditto	Ditto.
28	Annual Report of the Department of Agriculture, Bombay Presidency, for 1915-16. Price As. 10 or 11*d*.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
29	Season and Crop Report of the Bombay Presidency for 1915-16. Price As. 5 or 6*d*.	Ditto	Ditto.
30	Fodder Crops of Western India. Bulletin No. 77 of 1916 of the Department of Agriculture, Bombay. Price As. 11-3 or 1*s*. 1*d*.	Harold H. Mann, D. SC., Principal, Agricultural College, Poona.	Ditto.
	Some wild fodder plants of the Bombay Presidency. Bulletin No. 78 of 1916 of the Department of Agriculture, Bombay. Price As. 13 or 1*s*. 3*d*.	W. Burns, D. SC., Economic Botanist, Bombay.	Ditto.
32	Cultivation of Guavas in Gujarat. Bulletin No. 79 of 1916 of the Department of Agriculture, Bombay. Price As. 5-6 or 6*d*.	L. B. Kulkarni, L. Ag. Agricultural Department, Bombay.	Ditto.
33	Report on the Operations of the Department of Agriculture, Madras Presidency, for the year 1915-16. Price As. 3 or 3*d*.	Issued by the Department of Agriculture, Madras	Government Press, Madras.
34	Season and Crop Report of the Madras Presidency for the year 1915-16. Price As. 4 or 6*d*.	Ditto	Ditto.
35	Report of the work of the Anakapalli Agricultural Station for 1915-16. Price As. 1-6 or 2*d*.	Ditto	Ditto.
36	Report of the work of the Taliparamba Agricultural Station for 1915-16. Price 1 anna or 1*d*.	Ditto	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
37	Report of the work of the Samalkota Agricultural Station for the year 1915-16. Price As. 2-6 or 3*d*.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
38	Report of the work of the Palur Agricultural Station for the year 1915-16. Price As. 2-6 or 3*d*.	Ditto ..	Ditto.
39	Report of the work of the Koilpatti Agricultural Station for the year 1915-16. Price As. 1-6 or 2*d*.	Ditto	Ditto.
40	Report of the work of the Hagari Agricultual Station for the year 1915-16. Price As. 2-6 or 3*d*.	Ditto .	Ditto.
41	Report of the work of the Coimbatore Agricultural Station for the year 1915-16. Price As. 2 or 2*d*.	Ditto ..	Ditto.
42	Report of the work of the Manganallur Agricultural Station for the year 1915-16. Price As. 2 or 2*d*.	Ditto	Ditto.
43	Report of the work of the Nandyal Agricultural Station for the year 1915-16. Price 1 anna or 1*d*.	Ditto ...	Ditto.
44	Report of the work of the Sirvel Agricultural Station for the year 1915-16. Price 1 anna or 1*d*.	Ditto ...	Ditto.
45	Pulichai, Mailam, or Jari Cotton. Leaflet No. 5 of 1916 of the Department of Agriculture, Madras.	G. A. D. Stuart, I. C. S., Director of Agriculture, Madras.	Ditto.
46	Report on the Working of the Department of Agriculture, Central Provinces and Berar, 1915-16. Price R. 1 or 1*s*. 6*d*.	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
47	Season and Crop Report of the Central Provinces and Berar for 1915-16. Price As. 8 or 9*d*.	Ditto	Ditto.
48	Report on the Management of the Provincial and District Gardens in the Central Provinces and Berar for 1915-16. Price As. 4 or 4*d*.	Ditto ...	Ditto.
49	Report on Agricultural Stations, Southern Circle, for 1915-16. Price R. 1.	Ditto ...	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
50	Report on Agricultural Stations, Northern Circle, for 1915-16. Price As. 8.	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
51	Report on Agricultural Stations, Western Circle, for 1915-16. Price As. 8.	Ditto .	Ditto.
52	Report on Experimental Farm attached to the Agricultural College, Nagpur, for 1915-16. Price As. 8.	Ditto .	Ditto.
53	Report on Demonstration Work in the Southern Circle for 1915-16. Price As. 8.	Ditto	Ditto.
54	Report on Demonstration Work in the Northern Circle for 1915 16. Price As. 8.	Ditto ..	Ditto.
55	Report on Demonstration Work in the Western Circle for 1915-16. Price As. 8.	Ditto ...	Ditto.
56	Report on Agricultural College, Botanical and Chemical Research, Central Museum, Nagpur, Entomological Work and Maharajbagh Menageries for 1915-16. Price As. 8.	Ditto ...	Ditto.
57	The *Agricultural and Co-operative Gazette* (Monthly) from August, 1916, to January, 1917. Price As. 2 per copy.	Ditto ...	Shalom Press, Nagpur.
58	Report on the Operations of the Department of Agriculture, Burma, for the year ending 30th June, 1916. Price As. 6 or 7*d*.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
59	Report of the Hmawbi Agricultural Station for 1915-16.	Ditto ...	Ditto.
60	Report of the Tatkon Agricultural Station for 1915-16.	Ditto ...	Ditto.
61	Report of District Work in the Northern and Southern Circles, Agricultural Department, Burma, for the year ending 30th June, 1916.	Ditto ...	Ditto.
62	Minutes of the ninth Half Yearly Conference of the Agricultural Department held at Maymyo on the 10th and 11th August, 1916.	Ditto ..	Ditt
63	Annual Report of the Department of Agriculture, Assam, for the year ending 30th June, 1916. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printin Office, Shillong.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
64	Annual Report of the Jorhat Agricultural Experiment Station for the year ending 30th June, 1916.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
65	Annual Report of the Upper Shillong Agricultural Station, for the year ending 30th June, 1916.	Ditto ..	Ditto.
66	Annual Report of the Kamrup Sugarcane Experiment Station for the year ending 30th June, 1916.	Ditto ..	Ditto.
67	Annual Report of the Karimganj Agricultural Experiment Station for the year ending 30th June, 1916.	Ditto ...	Ditto.
68	Annual Report of the Fruit Experiment Station, Shillong, for the year ending 30th June, 1916.	Ditto ...	Ditto.
69	Annual Report of the Agricultural Experiments and Demonstrations in Assam for theyear ending 30th June, 1916.	Ditto ...	Ditto.
70	Report on the Season and Crops of the North-West Frontier Province for 1915-16. Price As. 10 or 1*s.*	Issued by the Department of Agriculture, North-West Frontier Province.	Government Press, Pesha-
71	Summary of Remarks on the *Kharif* Crop of the North-West Frontier Province for 1916. Price As. 4 or 4*d.*	Ditto	Ditto.
72	The *Journal of the Madras Agricultural Students' Union* (Monthly). Annual subscription, R. 1.	Madras Agricultural Students' Union, Coimbatore.	Literary Sun Press, Coimbatore.
73	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphanage Press, Calcutta.
	The *Journal of Dairying and Dairy-Farming in India* (Quarterly.)	Published by the Indian Committee of the Dairy Education Association.	Messrs. Thacker, Spink's Press, Calcutta.
75	*Poona Agricultural College Magazine.* (Quarterly.) Annual subscription, Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	AGRICULTURAL CHEMISTRY.		
76	The Insects attacking Stored Wheat in the Punjab, and the Methods of combating them (including a Chapter on the Chemistry of Respiration). Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IV, No. 6. Price Rs. 3-8 or 5*s.* 6*d.*	J. H. Barnes, B.SC., F.I.C., F.C.S., Principal, Punjab Agricultural College, and Agricultural Chemist to the Punjab Department of Agriculture; and A. J. Grove, M.SC., formerly Supernumerary Entomologist in the Imperial Department of Agriculture in India.	Messrs Thacker, Spink & Co., Calcutta.
77	The Gases of Swamp Rice Soils, Part IV. The Source of the Gaseous Soil Nitrogen. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. V, No. 1. Price Rs. 2 or 3*s.* 6*d.*	W. H. Harrison, D.SC. Government Agricultural Chemist, Madras; and P. A. Subramania Aiyer, B.A., Assistant to the Government Agricultural Chemist.	Ditto.
78	A Preliminary Chemical Study of the Rices of Bihar and Orissa. Bulletin No. 62 of the Pusa Agricultural Research Institute. Price As. 4 or 5*d.*	Jatindra Nath Sen, M.A., F.C.S., Officiating Imperial Agricultural Chemist.	Government Printing, India, Calcutta.
79	A Study in the Assimilation of Nutrients by the Rice Plant. Bulletin No. 65 of the Pusa Agricultural Research Institute. Price As. 2 or 3*d.*	Ditto	Ditto.
80	Notes on Improved Methods of Cane Cultivation. Bulletin No. 35 of the Department of Land Records and Agriculture, United Provinces. Price A. 1.	G. Clarke, F.I.C., and Naib Hussain.	Government Press, United Provinces, Allahabad.
	BOTANY.		
81	The Wheats of Baluchistan, Khorasan, and the Kurram Valley. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VIII, No. 1. Price R. 1-12 or 2*s.* 6*d.*	Gabrielle L. C. Howard, M.A., Second Imperial Economic Botanist.	Messrs. Thacker, Spink & Co., Calcutta.
82	Observations on the Inheritance of Anthocyan Pigment in Paddy varieties. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VIII, No. 2. Price R. 1 or 1*s.* 6*d.*	G. P. Hector, M.A., B.SC., Economic Botanist to the Government of Bengal.	Ditto.
83	Pollination and Cross-fertilization in the *Juar* Plant. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VIII, No. 4. Price R. 1 or 1*s.* 6*d.*	R. J. D. Graham, M.A., B.SC., Economic Botanist, Central Provinces.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

MYCOLOGY.

No.	Title	Author	Where published
84	*Phytophthora* on *Heavea Brasiliensis.* Memoirs of the Department of Agriculture in India, Botanical Series. Vol. VIII, No. 5. Price As. 12 or 1*s*.	Jehangir Fardunji Dastur, B.Sc., First Assistant to the Imperial Mycologist.	Messrs. Thacker, Spink & Co., Calcutta.
85	*Phytophthora* on *Vinca rosea.* Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VIII, No 6. Price As. 8 or 9*d*.	Ditto	Ditto.

ENTOMOLOGY.

No.	Title	Author	Where published
86	Instructions for rearing Mulberry Silk-worms. Bulletin No. 39 of the Pusa Agricultural Research Institute. Second (Revised) Edition. Price As. 8 or 9*d*.	M. N. De, Sericultural Assistant, Pusa.	Government Printing, India, Calcutta.
87	*Resham—Shilper Unnatikalpé Tutbhook Resham Keetjati Sambandhe Pratham Bibaranee.* The purport of the author's English Bulletin, No. 48.	Ditto	India Press, Calcutta.
	A Guide to Successful Bee-keeping in the Hill Districts of Northern India. Price As. 4 or 4*d*.	Lieut. F. S. Cousins.	Government Printing, Punjab, Lahore.

AGRICULTURAL BACTERIOLOGY.

No.	Title	Author	Where published
89	A Modified Method of Green-manuring. Bulletin No. 63 of the Pusa Agricultural Research Institute. Price As. 2 or 3*d*.	C. M. Hutchinson, B.A., Imperial Agricultural Bacteriologist.	Government Printing, India, Calcutta.

VETERINARY.

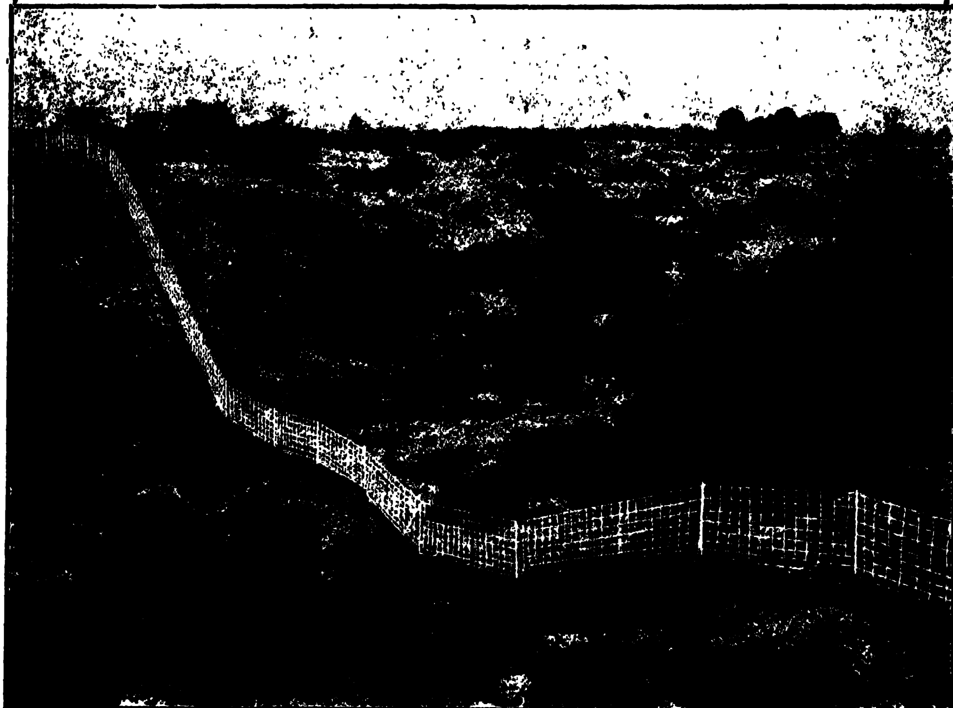
No.	Title	Author	Where published
90	Annual Report of the Imperial Bacteriologist, Muktesar Laboratories, for the year 1915-16. Price As. 4 or 5*d*.	Issued by the Agricultural Adviser to the Government of India, Pusa.	Government Printing, India, Calcutta.
91	A Comparison of the "Defibrination" and "Oxalate" Methods of Serum Preparation as applied to Hæmorrhagic Septicæmia and Anthrax Sera together with some Analyses of Buffalo and Hill Bull Blood. Bulletin No. 60 of the Pusa Agricultural Research Institute. Price As. 3 or 4*d*.	R. V. Norris, M. Sc., D. Sc., F. I. C., Physiological Chemist, Muktesar Laboratory.	Ditto.
92	Rinderpest—Preparation of Anti-Serum. Bulletin No. 64 of the Pusa Agricultural Research Institute. Price As. 3 or 4*d*.	A. W. Shilston, M. R. C. V. S., Assistant Bacteriologist incharge of the office of Imperial Bacteriogist. Muktesar Laboratory.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*Contd.*

No.	Title	Author	Where published
	Veterinary—Contd.		
93	Annual Report of the Bengal Veterinary College and of the Civil Veterinary Department, Bengal, for 1915-16. Price As. 7 or 8*d*.	Issued by the Civil Veterinary Department, Bengal.	Bengal Secretariat Book Depôt, Calcutta.
94	Annual Report on the Punjab Veterinary College, Civil Veterinary Department, Punjab, and the Government Cattle Farm, Hissar, for 1915-16. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
95	Annual Report of the Camel Specialist, Punjab, for 1915-16. Price As. 3 or 3*d*.	Ditto	Ditto.
96	A Note on the action of Purgatives on the Camel.	H. E. Cross, M.R.C.V.S., D.V.H., A.SC., Camel Specialist, Sohawa.	Ditto.
97	Report of the Bombay Veterinary College and Civil Veterinary Department, Bombay Presidency, including Sind, for 1915-16.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
98	Annual Administration Report of the Civil Veterinary Department, Madras Presidency, for 1915-16. Price As. 12 or 1*s*.	Issued by the Civil Veterinary Department, Madras.	Government Press, Madras.
99	Some common ailments of Cattle. Leaflet No. 11.	F. Ware, Superintendent, Civil Veterinary Department, Madras.	Ditto.
100	Report of the Civil Veterinary Department including the Insein Veterinary School, Burma, for the year ending 31st March 1916. Price As. 8 or 9*d*.	Issued by the Civil Veterinary Department, Burma.	Government Printing, Burma, Rangoon.
101	Report of the Civil Veterinary Department, Assam, for 1915-16. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
102	Manual of the Civil Veterinary Department, Central Provinces and Berar. Price R. 1.	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.

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Report of the Imperial Department of Agriculture in India for the years 1905-06 and 1906-07. Price, As. 6 or 7*d*.

Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the years 1907-09. Price, As. 4 or 5*d*.

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Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1910-11. Price, As. 6 or 7*d*.

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Report on the Progress of Agriculture in India for the years 1907-09. Price, As. 6 or 7*d*.

Report on the Progress of Agriculture in India for the year 1909-10. Price, As. 6 or 7*d*.

Report on the Progress of Agriculture in India for the year 1910-11. Price, As. 12 or 1*s*. 3*d* (*Out of print.*)

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Report on the Progress of Agriculture in India for the year 1912-13. Price, As. 8 or 9*d*.

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Proceedings of the Board of Agriculture in India, held at Pusa on the 6th January 1905 and following days (with Appendices). Price, As. 8 or 9*d*.

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Proceedings of the Board of Agriculture in India, held at Pusa on the 17th February 1908 and following days (with Appendices). Price, As. 8 or 9*d.*

Proceedings of the Board of Agriculture in India, held at Nagpur on the 15th February 1909 and following days (with Appendices). Price, As. 8 or 9*d.*

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Proceedings of the Board of Agriculture in India, held at Pusa on the 20th November 1911 and following days (with Appendices). Price, As. 10 or 1*s.* (*Out of print.*)

Proceedings of the Board of Agriculture in India, held at Coimbatore on the 8th December 1913 and following days (with Appendices). Price, R. 1-2 or 1*s.* 9*d.*

Proceedings of the Board of Agriculture in India, held at Pusa on the 7th February 1916 and following days (with Appendices). Price, R. 1-2 or 1*s.* 9*d.*

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Supplement to the Agricultural Journal of India,

July 1917.

THE HON'BLE SIR CLAUDE HILL ON AGRICULTURAL PROGRESS.

In his Budget speech at the meeting of the Imperial Legislative Council on 10th March, 1917, The Hon'ble Sir Claude Hill, Member in charge of the Department of Revenue and Agriculture, Government of India, spoke as follows :—

"Turning now to Agriculture, the first subject to which I propose to refer is agricultural education. This Council will remember that last year I explained that we had then recently had a conference on agricultural education in Pusa in February 1916, and I gave an outline of one or two of the more important resolutions which that conference had come to. Those resolutions were, as I then foreshadowed, referred to Local Governments for opinion, and we have since received their views, which are under consideration. Well, Sir, it seems to me that we have now reached a stage at which it is not only possible but necessary that the Government of India should formulate and promulgate their conclusions on this important subject ; and I propose, in order to lead up to the possibility of such promulgation—and I have in this His Excellency's concurrence—to convene a conference on agricultural education to assemble in Simla some time during the ensuing summer, to be composed of expert agriculturists, expert educationists and some, I hope, Additional Members who are interested in the subject and whom I shall invite ; and I hope that with their assistance the Government of India will be placed in a position in which they can formulate their conclusions in regard to a definite policy and inculcate them upon Local Governments. I wish to mention that, in arriving at this stage of our proposals, I have received the most valuable

assistance from my Hon'ble friend, Pandit Madan Mohan Malaviya, to whose suggestions I am very greatly indebted for the scheme of consultation which I have outlined.

"Last year I referred to the meeting of the Board of Agriculture which had taken place shortly before the meeting of this Council. The Board, as this Council is aware, only meets biennially, and therefore there was no meeting of the Board this year. Such meetings are, however, of such value for scientific purposes that, on Mr. Mackenna's advice, I arranged this year to have sectional meetings of some of the scientists under the Agricultural Department, and there has recently been held, under Mr. Mackenna's presidency, a meeting of entomologists and mycologists, which, Mr. Mackenna informs me, has got through a very large amount of very useful work.

"From time to time, as I hinted just now, the press seems inclined to question whether practical agriculture gets the advantage from scientific research to which ordinarily it should be entitled. I think this criticism proceeds, partly at all events, from ignorance of what is being done; and, as I have already said, I do not reproach our critics on account of that ignorance, because I do not think we have always taken the steps necessary to enlighten them. But we have recently issued two publications, one the *Agricultural Journal of India* which issues quarterly, and one the 'Report on the Progress of Agriculture in India.'

"Well, I hold those two publications in my hand, and I would suggest that those Hon'ble Members and the general public, who may be interested in these subjects and wish to make inquiries and inform themselves regarding them and as to the scientific progress that has been made and so forth, should subscribe regularly to our Agricultural Journal. I am afraid I am a bad advertiser, but I appeal to Hon'ble Members not only to do this, but also, if they will, to send me any criticisms or suggestions they may have to make regarding the further improvement of these hand-books.

They are profusely illustrated and quite neatly got up, and I hope Hon'ble Members will appreciate the change from the ordinary foolscap blue-book type of publication.

"With regard to the question whether any practical benefits have resulted from scientific investigations, I think I can give one or two practical and conclusive answers based on information which Hon'ble Members will get from Chapter III of 'Progress of Agriculture in India.' For example, Pusa wheat No. 12, as demonstrated by Mr. Howard, has resulted in an increased profit to cultivators of roughly speaking Rs. 12 an acre as compared with those cultivators who cultivate the ordinary *desi* wheat. Needless to say, this represents a very, very large excess profit to cultivators of wheat. I should like to take this opportunity, in reference to Pusa wheat No. 12 and its spread, to thank those zemindars and landholders of the province of Oudh who have been foremost in helping the Department to popularize this wheat and to spread its cultivation, and in particular my Hon'ble friend, Raja Sir Rampal Singh Bahadur, who has placed under the supervision of the Department about 50 acres to be used for a seed farm. I had the pleasure of visiting that seed farm a little while ago and also seeing, on my way through the Rai Bareilly district, the progress that has been made. The co-operation of the zemindars in Oudh in this matter and the public spirit displayed are deserving of the highest commendation, and I hope their example will be followed in other parts of India.

"In reference to a question which was asked in this Council which seemed to imply that we were wrong in sending home parcels of wheat for milling experiments in England, to which I replied by a reference to the answer given to a similar question in the United Provinces Council, I should like to explain that it is quite obvious that if we can secure that any wheat from India is graded and standardized and recognized in Europe as being of a particular quality, we shall by those means popularize the product and shall also eventually,

and at no distant date, secure to the cultivator a very much more permanent as well as enhanced return. I should have hardly thought that that required demonstration, since it seems to me quite an obvious reply, and the small quantities which have been sent home, hardly diminish the rate of development of the sowing of this seed, at all events not comparably with the advantages which are inherent in standardizing it at home. There is, however, another justification and another reason for sending these samples home, and that is this. This Council are aware probably that Indian produce in the past, seeds and so forth, have had a very bad reputation owing to the practice which used to prevail almost universally of mixing a certain amount of dirt with the produce ; so much so that eventually and for a large number of years, it was necessary in computing the value of Indian produce to *assume* that it contained a certain percentage—averaging 2 per cent.—of dirt. This, I hope, is a thing of the past, but I think the very existence of that practice within recent years is a sufficient justification, if further justification were needed, for taking steps to assure the English millers that what purports to be Pusa wheat No. 12 is really that, and not mixed with a certain amount of impurity.

"Similarly, in regard to cotton, scientific experiments, especially in the Central Provinces, have resulted in a great improvement in the development of short staple cotton, an improvement which is computed to have given the ryots a profit of approximately Rs. 15 an acre. This, spread over the whole area, means that the ryots in the Central Provinces are benefited to the extent of very many lakhs of rupees. Again in the Punjab, No. 4-F American cotton has been in the past year sold at a premium of Rs. 2-8 to Rs. 4 a maund, and is now making rapid strides in popularity. The importance to the Empire of developing the out-turn of long staple cotton is such that the Government of India have determined, or at all events have proposed, and I hope it will result in



THE HON'BLE SIR CLAUDE HAMILTON ARCHER HILL, K.C.S.I., C.I.E., I.C.S.,
Member in charge of the Department of Revenue and Agriculture, Government of India.

determination, to convene next October a special committee to examine the subject of long staple cotton and to visit the chief cotton-growing centres and ginning factories and so forth, and to report to the Government of India as to the best means of securing the extension of long staple cotton cultivation.

"This question of long staple cotton brings me to the question of marketing which is a subject of great difficulty to which the agricultural departments have given a great deal of attention. We of course desire that the cultivator should reap the full benefit of any improvements which we can devise for him in the matter of cultivation; but occasionally, and especially in regard to cotton, efforts are made by buyers to defeat our object in that regard. There is an instance that I may mention; last year at Lyallpur, a ring of buyers endeavoured to defeat our desire to secure adequate prices for American cotton, long staple, grown in the Punjab; and the Agricultural Department of the Punjab had to organize special auction sales, and succeeded, as I have just said, in securing that cultivators realized a premium of Rs. 2-8-0 to Rs. 4. This resulted mainly through the co-operation of certain firms, such as Messrs. Tata & Co. That will illustrate the difficulties which we have to contend with in the matter of securing to the cultivator the advantage which is his due. I do not wish to claim these achievements in the matter of cotton and wheat as conclusive or final or as being so creditable as to disarm criticism. They really are much more the earnest of what we hope to do. The potentialities emphasize of course the need—and this is a very important point—for securing the services of the best possible men for the agricultural department, and this aspect of the case reacts upon the question of recruitment. This was one of the subjects which we discussed at the informal conference to which I have referred, and I think all Hon'ble Members came to the conclusion that the position was roughly that, first of all, we must secure for the

Agricultural Department in India the best possible and most devoted workers, irrespective of race, creed or anything else, but secondly, subject to that proviso, which will exist until we have advanced somewhat further along the road of progress, we should make every effort to recruit and to find suitable Indians for those posts. This is a very important matter which will of course have to be taken into consideration at the conference which I propose to hold in Simla. But I think Hon'ble Members and the general public could very largely assist in this matter if they would only urge upon the people at large the desirability of some of the best brains of the country taking up such subjects as agriculture and forestry in which so much remains to be done to develop the potential prosperity of the country, and I hope Hon'ble Members will endeavour to make known this aspect of the case. We need the best brains we can get.

"My Hon'ble friend, Mr. Wacha, asked a question in this Council on the subject of agricultural engineering, and I was compelled to reply to him that I thought that the stage to which agriculture had advanced in India did not justify us in proposing to establish separate special agricultural engineering institutes at present.

"I hope my Hon'ble friend will agree with me in this conclusion, but I hope that this development will follow in due course as soon as we have organized ourselves to the stage when we can provide for specialization of that kind. In the meantime we are sanctioning the strengthening of the staff at a considerable rate as the following will show. During the year we have sanctioned an Entomologist for the Punjab, a Soil Physicist for the Bombay Presidency, a special Deputy Director of Agriculture for cattle-breeding and dairying in Madras, a fourth Deputy Director for cattle-breeding in the United Provinces, a third Deputy Director of Agriculture for Bengal, and the continuance for a further period of five years of the appointment of Assistant Economic Botanist in the United Provinces. Most of these appointments

of course have to remain vacant, not only because of the economies imposed by the war, but owing to the unfortunate fact that we cannot find recruits at the present time to fill the posts. As soon as the war is over, we hope that there will be plenty of recruits, and that we shall get the staff needed. Not only have we sanctioned these individual posts, but we have taken the initiative in another direction, that is, by suggesting to Local Governments the desirability of each province being self-contained in the matter of its Agricultural Department; in other words, that each province should be able on its own account and with its own staff to carry out all the experiments and processes that may be necessary for its own agriculture, whether it be agricultural education or experimentation or demonstration; and we have suggested a schedule minimum to Local Governments which, I feel fairly confident, will be responded to.

"I now turn to the silk industry. I mentioned last year that we had obtained the services of Mr. Maxwell-Lefroy to investigate the silk industry of India. Mr. Maxwell-Lefroy has written what, I hope, will prove to be a monumental report on the silk industry. Unfortunately he was interrupted, unfortunately that is for the Agricultural Department, by a call made on him by the military authorities to proceed to Mesopotamia to endeavour to grapple with the plague of flies which prevailed there last year. Mr. Maxwell-Lefroy was absent for two months, and the result was that he was unable to proceed to Japan to complete the tour which he had projected in investigating the silk industry. He had rather hurriedly to compile his report, but I hope his labours, coupled with those of Mr. Ansorge, who co-operated with him on the commercial side, will prove of great value to the country. The only definite conclusion (I have not seen his report in its final form), which I know that Mr. Lefroy has come to, is that the silk industry, as such, cannot stand by itself probably, in any province, and must be regarded as a sort of by-product of the ordinary agricultural work of

the cultivator. That is a proposition which does not affect the question of course or the desirability of resuscitating the industry, but it is a material fact as to the methods by which such resuscitation may best be effected.

"Last year I also mentioned that we proposed to secure the services of a special indigo chemist for the investigation of the indigo industry in regard to the methods of production of the natural indigo. Mr. Davis has been at work here for a year, and has already succeeded in producing a standardized paste of natural indigo, samples of which have been sent to England for test. The reports of the results of these experiments must be awaited; but his provisional results, coupled with other experiments which he has made in the matter of vatting in conjunction with the Imperial Agricultural Bacteriologist, have raised in the minds of the Government of India the sincere hope that it may yet be possible to re-establish the natural indigo industry on a footing in which it will be able to compete on equal terms with synthetic. That being so, it seems imperative that the work done by Mr. Davis should continue; he has really only begun the scientific side of it. It is proposed by the planters of Bihar, which is the original home of the indigo industry in India, it is proposed by them that he should be retained for a further period, and that he should be associated with a special indigo botanist, since the botanical side of the problem requires to be further investigated. For that purpose the Bihar planters have suggested, in order to finance this investigation, the imposition of a small export duty on raw indigo. The proposal has been referred to the Local Governments concerned, who with one exception (and I hope a temporary exception) have agreed in the desirability of doing this, and I need hardly impress upon this Council the importance, if possible, of retaining or recovering an industry of such value to India as the indigo industry."

* * * * * * *

"Since my Hon'ble friend, Sir William Meyer, delivered his speech on the 1st of March, we have received the Secretary of State's sanction to our proposals for the distribution of the profits from the Wheat Scheme which, Hon'ble Members will remember, we undertook should be devoted for the benefit of agriculture, more particularly in those provinces where wheat was grown. A sum of £158,000 (Rs. 23,70,000) will be distributed in the following manner :—

	Rs.
Punjab will receive	10,70,000
United Provinces	7,75,000
Central Provinces	2,25,000
Bombay	1,50,000
North-West Frontier Province	50,000
The Agricultural Adviser	1,00,000

This distribution has been effected after consultation with the Local Governments, and on a basis partly of the area under wheat in the different provinces and of the amount exported, as also of the existing agricultural needs, specially with reference to wheat, of the different provinces. We have reserved one lakh of rupees to the Agricultural Adviser as a reserve on which to draw in the event of any emergent matter appearing which conforms to the conditions on which we have decided to allot such grants."

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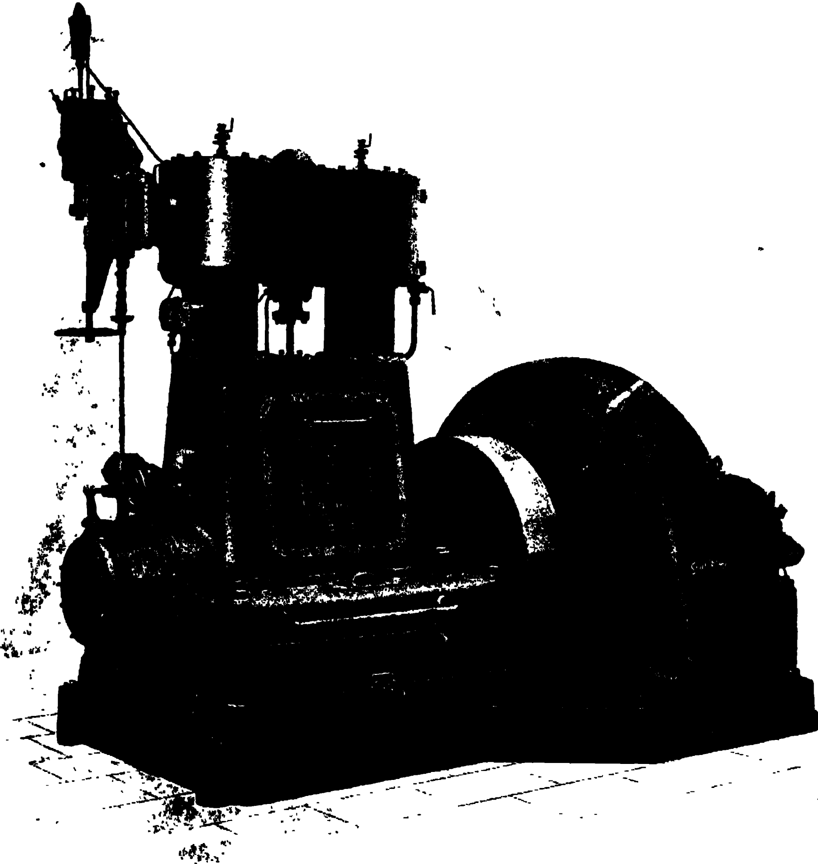
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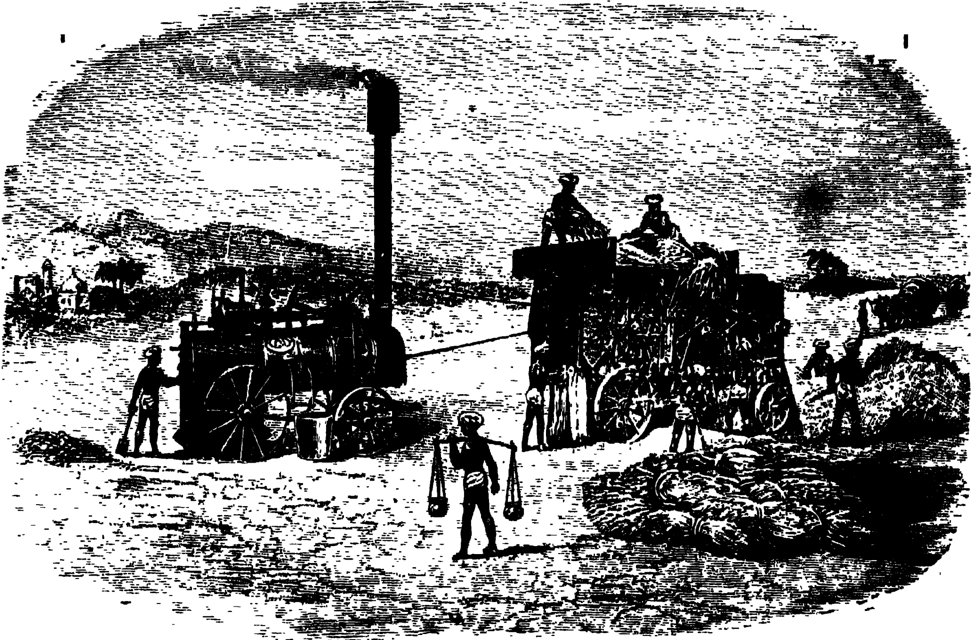
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IN the course of a speech at a Darbar held on the 16th April, 1917, at Lahore, His Excellency the Viceroy said :—

" I have referred to the part which the Punjab is playing in the war. I now turn to the still greater part which it may play in the realm of peace. The prosperity of India is, and must be for many years to come, dependent mainly on her agriculture. The natural advantages of climate and soil, the abundance of labour, the industry and thrift of the peasantry, the provision through Government agency of a generous water-supply, and the accumulated experience of generations engaged in practical husbandry have enabled her not only to feed her vast population but to produce a large surplus for export and thus to purchase a steadily increasing amount of foreign manufactures. But the growing pressure of population on the soil, together with a progressive rise in the standard of living, makes it essential for her to increase her production per acre if her rate of progress is to be maintained. In Europe and Northern America science has made great strides in this direction, and the small but promising beginnings made by research workers in this country show what immense possibilities lie before us. The Punjab has peculiar advantages for leading the way. The huge areas brought under irrigation by the canals provide an ideal field for improved methods of agriculture. Your cultivators are enterprising and intelligent, but they are hampered by shortage of capital and the lack of scientific knowledge. Their traditions have inclined them to put quantity above

quality and to set more store by immediate returns than future possibilities. Let me suggest that if the desired increase of production is to be secured, improvements are necessary in three directions: (1) In the methods of cultivation, (2) in the selection of better varieties of the staple crops, and (3) in the harvesting and marketing of pure grades. The Agricultural Department is doing its best to introduce all these improvements and is meeting with a most encouraging degree of co operation. The superiority of its selected varieties of various crops, especially of wheat and American cotton, has already been proved. I hope that there will be a considerable expansion of research in this direction as soon as more workers are available. The importance of demonstrating the results so far obtained has recently been impressed on Local Governments, and the grant of Rs. 10,70,000 which has been made to the Punjab from the profits realized by the Government of India from the exports of wheat, should enable material progress to be made in the important work of demonstration. Government are also considering the question whether anything can be done to improve the arrangements for the marketing of cotton, so as to secure to the cultivator a full price for superior varieties. These are all matters in which the large landholders of the Province can render material assistance. You can stimulate improved methods of cultivation on and around your estates by example and precept; you can help your tenants to obtain the best varieties of seed by establishing seed farms in co-operation with the Department and so teach them the value of maintaining pure strains; and you can discourage the practice of adulteration, which has sullied the reputation of India's crops and prevents the cultivator from reaping the full value of his out-turn. In all these respects your help will be invaluable; in fact, rapid

progress will be impossible without it. Only a comparatively small number of people are able to visit the Government farms, and those who do go are always satisfied that they could produce the same results themselves. But when they see their neighbour adopting some reform, growing better crops, and getting more money for them, then they are readily converted and in their turn become apostles. It is by this means that I hope to see prosperity increase and spread in the fields of this fair province. First, the research of the scientists; second, demonstration by Government officers; and last, the intelligent activity of the cultivator bringing the seed sown by science to fruition in the field. A municipality or a company can generate electricity at a power-station and light the streets with it, but numberless wires are required to convey it to the houses of the people. It is the same with scientific agriculture. The discoveries of the laboratory are sterile until they are applied to practical cultivation. It is the privilege and the duty of the large landholder to pioneer the distributary wires that will bring the light of science to shine on the labours of the humble tiller of the soil."

PLATE XIX.



PICTURESQUE ROAD JUNCTION.
(Gondal State Gardens.)

Original Articles.

ORNAMENTAL GARDENING IN INDIA.*

BY

W. BURNS, D.Sc.,

Economic Botanist, Bombay,

AND

E. LITTLE,

Superintendent, Government House Gardens, Bombay.

The making of a garden is a matter of design. All design is a conscious attempt to produce a beautiful pattern in a given space. The pattern may be regular or irregular, symmetrical or asymmetrical, but it is still a harmonious whole, fulfilling the purpose of the designer.

In elucidating this ideal for India the writers are beset by two difficulties. First, India is a country with great differences of climate in its different parts; second, no two people hold quite the same opinions regarding the ornamental. The purpose of this article is to deal with principles in a common-sense way, and to record such facts of practical experience as seem generally useful.

Let us first consider some of the conditions of gardening in India.

The rainfall varies enormously in different tracts, from no rain to 300 inches per annum. Between such extremes there are all sorts of conditions and many possible types of garden. Some of the best gardens of India are those which depend wholly on irrigation and not at all on rainfall. In most areas artificial watering

* Received for publication on the 30th January, 1917.

is necessary for several months in the year. In many places the only source of this water is a costly pipe supply, and gardens must be limited in size and frequency. In other places irrigation water is received at intervals and the problem is one of storage. Again, in other places where well water is available the question is one of water-lifts.

The variation in temperature distribution makes any special remarks regarding it futile. The climate, however, is such that the time factor in gardening is of universal importance. When the air and soil are hot and humid, growth is so rapid that unless things are done betimes the garden gets out of hand. When the soil and air are hot and not humid, a few hours' drought or exposure may ruin many plants. When the rains are unusually heavy, lack of previous preparation in the way of terracing and drainage may mean destruction.

Fungoid and insect-pests are severe and must be unceasingly combated.

In different areas garden labour is of different value and experience, but is on the whole inefficient, ignorant, and unambitious. In Poona at present a real *mali* (gardener) is rare. Those who do the work of *malis*, especially in bungalow gardens, are mere unskilled coolies who pick up a smattering of gardening knowledge. They are often employed on miscellaneous jobs about the house in addition to their gardening work. Nevertheless, the pay of such a man is from Rs. 12 to Rs. 20 per month, due to the rise in wages which is partly attributable to the prices paid for unskilled labour by military and industrial concerns. The labour, skilled or unskilled, is not so efficient as in Europe. A single *mali* can satisfactorily look after a garden of not more than one-tenth of an acre. The bungalow *mali's* constant cry is for coolies to help him, and unless he and they are strictly and personally supervised they idle half the time. Such then are the conditions. Let us now consider the actual operations of ornamental gardening.

There is often no possibility of having a voice in the selection of the garden site. It has to be where the bungalow is placed or where the municipality or cantonment can give it a corner. Where

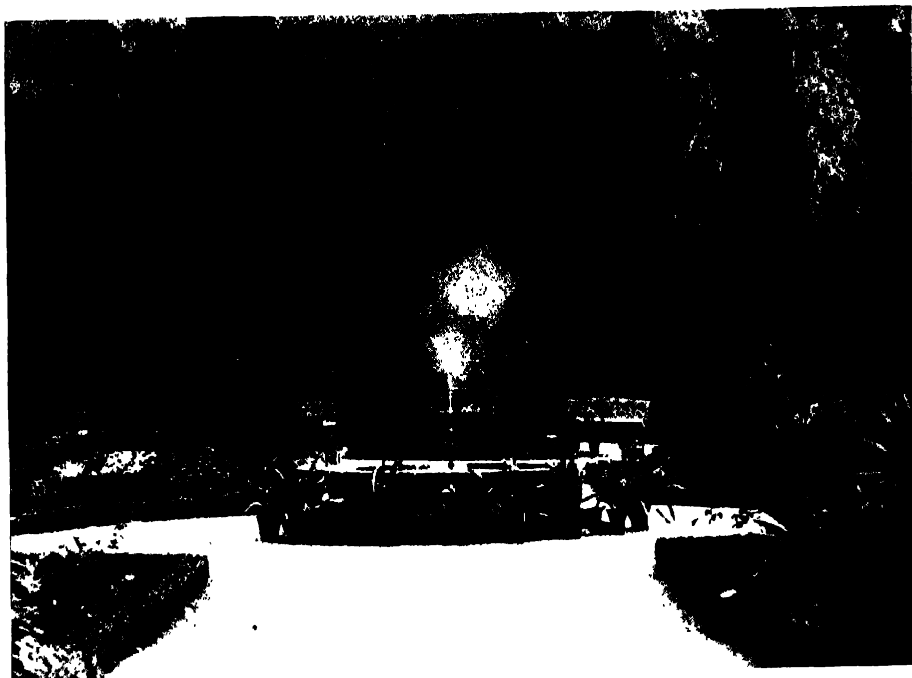


Fig. 1. TREES AS A BACKGROUND.
(Gondal State Gardens.)



Fig. 2. CONTRAST: ARCHITECTURE AND FOLIAGE.
(Junagadh State Gardens.)



Fig. 1. LAWNS, FLOWER-BEDS, BORDERS AND TREES.
(Government House Gardens, Poona.)



Fig. 2. FLOWER BORDERS AND TREES.
(Government House Gardens, Poona.)

freedom of choice exists, the following points should receive attention. The soil should be rich, at least three feet deep, with a porous substratum. Where there is very deep soil, the nature of the substratum is unimportant. Cheap water must be available in quantity. The site must be protected from wind. If not naturally protected, a windbreak must be grown as one of the early operations. Above all, in the case of a public garden, it must be accessible to those for whom it is intended. The subsequent treatment of the site depends largely on the climate and on the labour available. It is important to make the most of any natural features.

Let us now consider in detail—

(1) Roads and paths.
(2) Trees, shrubs, and hedges.
(3) Flower beds and borders.
(4) Pot plants.
(5) Climbers and epiphytes.
(6) Lawns.
(7) Water.
(8) Statuary and other non-living ornament.

1. Roads and Paths.

Given the site, the owner's next task is to lay out the roads and paths. No planting can be done till these are made, for coming and going of carts with road material would ruin plants already put out. The position of the roads must be determined by their function. Roads are required from the boundary to the door of the house, from the house to the stable and servants' quarters, from the house to the various parts of the garden, and from one part of the garden to another. The house is the normal centre of the roads. Roads well made at the start are most economical, as their upkeep costs less. It is more difficult to make and keep garden roads in India than in England. The continual weeding necessary and the great wash during the rains, loosen the surface and carry it off, and also create dust. In the Deccan the best walks are those made with a good foundation of stones of from four to six inches diameter, with a uniform layer of two-inch metal on top, bound

together with *murum* (disintegrated trap) and the whole finished off with a $\frac{3}{4}$-inch layer of gravel. Such a walk is easily weeded and does not become dusty. No attempt is made to consolidate the gravel. It is apt to be washed off during the rains, but can often be reclaimed. Stone-paved or concreted paths are hot and slippery. Where stone is not available broken bricks can be used as road-metal.

The modern common-sense view of roads is that it is silly to put curves in a road unless their necessity is obvious. On undulating ground the road will naturally wind along between the hillocks, but on a dead level it will be straight unless there are obstacles to be avoided. Too many straight walks may be avoided by planting groups of trees so that it appears that a curve was necessary to avoid them. The continuation of the walk, however, should be hidden from both sides or the curve will appear unnecessary and a short cut will quickly come into existence. Every Indian garden should have at least one shady walk as long as can be made—a place for that meditation and converse which arise from the pacing of a cloister.

2. Trees, Shrubs, and Hedges.

Trees are used in ornamental gardening as backgrounds, wind-breaks or screens (Plate XX, fig. 1), as frames for views, as groups or isolated specimens, and as avenues. After the road-making, tree planting should be taken up, so as to get the trees well established rapidly. In selecting trees for windbreaks only those species should be chosen which are known to do well in the particular environment concerned. The following are some plants used as windbreaks :—*Cassia siamea*, *Acacia arabica*, *Casuarina equisetifolia*, *Sesbania ægyptiaca*, *Dalbergia Sissoo*, *Dalbergia latifolia*, *Ficus retusa*, and *Hæmatoxylon campechianum*. In planting groups, the trees should not be planted at regular intervals, nor should the trees be all of the same species or size. If trees of the same species are planted in a group they should be of different dimensions. The best effect, however, is obtained when the trees of the group are of different species and contrast with each other in form and foliage. A group thus built up allows of the maximum effect of light and

PLATE XXII.



A POSSIBLE VISTA.
(Kotah State Gardens.)



Fig. 1. PERGOLA.
('Gladhurst," Poona : Residence of Sir D. J. Tata.)



Fig. 2. FLOWER BORDER, LAWN AND NON-LIVING ORNAMENT.
(Government House Gardens, Poona.)

shadow. Individual specimen trees should have room for full development and ample space around to enable their proportions to be seen. If such a tree is crowded by others at any time of its life it suffers permanently. It is necessary to take care that such specimen trees are not damaged in the young state. An isolated tree shows such damage much more distinctly than does a member of a group. Trees of scraggy growth do not make good specimen trees. The mango, the banyan, the mahogany, the gold mohur, and various *Cassias* are magnificent when grown as individual trees.

When planting avenues of slow-growing trees it is often desirable to put in trees of a quick-growing species alternately with the slow-growing kind. An effect is thus quickly obtained. The quick-growing trees should not be allowed to crowd the others and should be cut out completely when the others have attained a fair size. The trees should be allowed to meet over the roadway as early as possible. If the boughs over the roadway are cut away severely before this happens the result is a renewal of vegetative growth from low down. After the lower parts of the tree are fully shaded there is little growth there and pruning is unnecessary.

We do not propose to go into the pruning of trees, but would make one cautionary remark. Trees are planted in India in their permanent quarters when they are much smaller than trees planted in England. The Indian trees therefore need more careful attention, which as a rule they do not get.

Shrubs are of use as backgrounds to flower beds and borders. Large beds and borders may be entirely furnished with shrubs. Shrubs may even be used as individual plants on lawns or other open spaces. Among shrubs, as among trees, some are notable for their foliage and some for their flowers. The principles of grouping just enunciated hold good for shrubs also.

Hedges form a necessary undergrowth to boundary trees. No hedge is sufficient for effectively forbidding entrance to animals. Barbed wire is necessary. But a hedge is a useful second line of defence, and for this purpose spiky plants such as *Agave, Acacia arabica, Acacia Farnesiana,* and *Inga dulcis* are effective. For screens, avenues, and general effect *Duranta, Dodonæa,* Mulberry,

and *Hæmatoxylon* are excellent. Hedges should always be planted in double rows, the seedlings or cuttings of one row coming opposite the spaces in the other row. A foot between plants and a foot between rows is correct. The plants should be on ridges and the irrigation water should flow between these ridges. Hedges require to be broken or bent over when about two feet high to encourage thick growth low down.

3. Flower Beds and Borders.

With the great variety of flowers now at our disposal there is no garden in India that cannot be a blaze of colour for at least six months of the year. Flower beds are always most effective when adjacent to the house, or, in public gardens, to the main buildings therein. Flower beds may be cut in grass or surrounded by gravel, but should not be dotted about in a promiscuous manner. The best of all methods is to have a flower garden consisting of beds of more or less formal shape, the whole garden marked off on two or three sides by borders of flowers backed by shrubs or hedges. In India, during the rains at any rate, raised flower beds are a necessity. To some these appear inartistic, but it is more satisfactory to have vigorous plants than water-logged sickly ones.

A flowering border should be a mass of flowers not too formally arranged, tall at the back and dwarf at the front, with a variety of harmonizing colours. The border shown in Plate XXIII, fig. 2, is of this type. The plants composing it are :—

Tall. *Tithonia, Cosmos, Dahlia, Cleome speciosissima.*

Middle-sized. *Zinnia Haageana, Coreopsis tinctoria, Coreopsis Drummondii.*

Dwarf. *Tagetes patula, Gerbera Jamesoni, Coreopsis coronata.*

Prostrate. *Vitadenia australis.*

A bed bearing such a mass of vegetation must be well dug and manured, and the effect of the planting considered before the seedlings are inserted. Trees, shrubs, and flowering borders used in combination have a splendid effect along the two sides of a long path. The trees must be well back from the road and must not shade it, otherwise the flowers suffer and the effect is spoiled. A path may well end in a vista of the country beyond. (Plate XXII.)

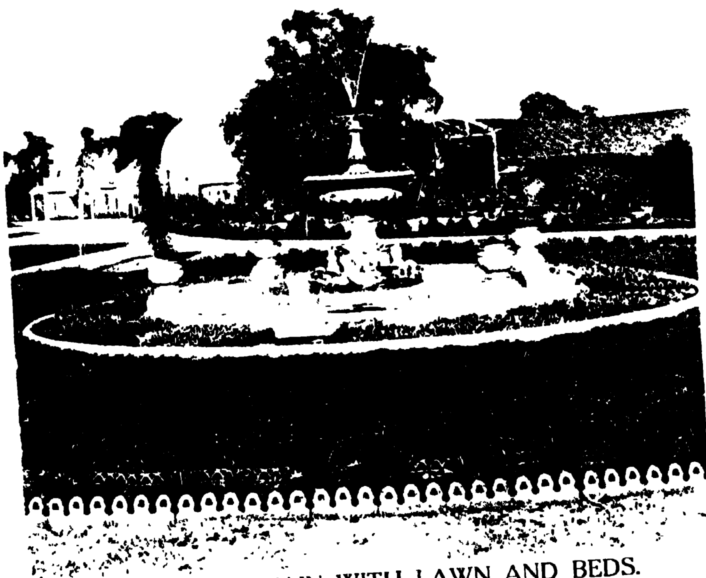


Fig. 1. FOUNTAIN WITH LAWN AND BEDS.
("Gladhurst," Poona: Residence of Sir D. J. Tata.)

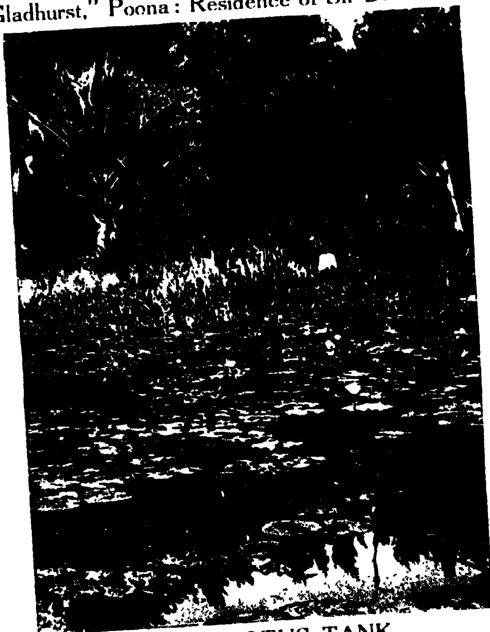


Fig. 2. LOTUS TANK.
(Government House Gardens, Poona.)



Fig. 1. LAWN AND TREES WITH ARCHITECTURE AND WATER.
(Jamnagar State Gardens.)



Fig. 2. EFFECT OF STATUARY: SACRED BULL ON PEDESTAL.
(Jamnagar State Gardens.)

4. Pot Plants.

The growing of plants in pots is understandable where there is no soil, as on a veranda or where the substratum is sheer rock. Yet we find many people, possessing gardens with admirable soil, who concentrate their attention on pots and neglect the good earth. The reason may be that pot plants can be sold when the owner leaves the station, and that a newcomer can, by purchasing pot plants, get some ready-made foliage quickly. Pot plants need more care than plants in the soil, and are in a more artificial situation. Plants in the soil are infinitely easier to cultivate. Again, it is difficult to make pot plants look artistic. The idea of some people seems to be to arrange the pot plants as a guard along a road or in regular ranks on a disused tennis court. Telegraph insulators or empty bottles would do equally well. For special places, however, such as a veranda or its steps, a hall, a gravel sitting-out place, or a conservatory platform, pot plants are essential. A nursery must be created where these plants can be propagated till they are of a size proportionate to the pots intended for them, and where sick plants can be nursed back to health. The composition and renewal of the soil in pots and the watering of pot plants are special points which cannot be treated here. Suffice it to say that water must be given in such a way as not to drive out the soil, and that the soil must be kept well mulched. The growing of roses in pots is also a special subject and must be passed over at present.

5. Climbers and Epiphytes.

For verandas, walls, pergolas, trellis work, pillars, arches and tree trunks, climbers make the most charming adornments. (Plate XXIII, fig. 1.) They refuse to be formal, and for this reason are perhaps most effective when clinging to some object of clear cut outline such as a stone pillar or gateway. *Bignonia gracilis* (otherwise *Bignonia unguis-cati*) and *Ficus stipulata* take to stonework without support. Rampant climbers on pergolas and trellis work must be kept within bounds by pruning, and old dead leaves must be at once removed. Occasionally it is possible to screen entirely some ugly bamboo matting or corrugated iron by means of a climber. For this purpose *Ipomea palmata* has few rivals.

Epiphytes are possible only on the trunks of trees in districts that suit them. In humid climates orchids may be used. In drier areas *Bilbergia* and other Bromelias may be employed. Along with ferns and climbers, Epiphytes help to beautify shady spots.

6. Lawns.

In most parts of India the making and upkeep of lawns are expensive items. Lawns cannot exist unless the soil is constantly moist and constantly weeded. Even with this care complete renewal every third year is often essential. For all districts *Cynodon dactylon* (*dub* or *hariali* grass) is the best lawn grass. *Dub* lawns may be made by the transplanting of turves, by dibbling, by spreading mud mixed with chopped plants, and by seed. Seeding does not seem to have been properly tested. The transplanting of turves has been done with marked success in some places, but generally it is impossible to get satisfactory turves. Resort is usually had to dibbling or spreading mud mixed with chopped plants. These methods are successful if the ground has been previously well cleaned and levelled, and arrangements made to carry off surplus rain water. It has been found useful to remove the top three inches of soil from the site of the lawn and heat it slowly for a day or two over a fire of garden rubbish, thus destroying all weed seeds and tubers lying in that layer of soil. The soil is not baked but is heated to about 60°C. This heated soil is replaced and the lawn planted. Weeds, however, are nearly always mixed up with the *dub* planted and must be eradicated as they appear. The smooth green carpet of a lawn is admirably adapted for filling up open spaces near to or visible from the house. Small lawns with flower beds are also used with excellent effect for beautifying the sides and junctions of main roads in the Quetta cantonment. (Plate XXVII, fig. 1.) One or two individual trees look well on a lawn and have no ill effect on it, but extensive shade must be avoided.

7. Water.

Here we most clearly meet formality and its opposite. Plate XXIV, fig. 1, shows the first and Fig. 2 in the same plate, the

PLATE XXVI.



GROUP OF STATUARY IN CONSERVATORY.
("Gladhurst," Poona: Residence of Sir D. J. Tata.)



Fig. 1. DECORATIVE EFFECT OF OLD CANNON (Quetta.)



Fig. 2. USE OF JAPANESE LANTERN.
("Gladhurst," Poona: Residence of Sir D. J. Tata.)

second. Both are beautiful. There is no more lovely sight than a pond filled with lotuses and backed by reeds and palms. Such a pond can be contrived in a low-lying spot and is most charming when secluded. The formal fountain or reservoir is intended for publicity and must be in a prominent place. Here all designs of aquatic gods and beasts are permissible. Plate XXV, fig 1, shows the extraordinarily decorative effect ot water *per se*.

8. Statuary and Non-living Ornament.

The employment of statuary requires considerable taste. It is obviously undesirable to erect a statue of a man struggling with a python in a spot intended as the abode of peace. The figure of a sylvan deity peering through the leaves is, however, quite in keeping with the spirit of the place. The sacred bull on its pedestal in Plate XXV, fig. 2, is a fitting piece of ornament. The little group in the conservatory (Plate XXVI) enhance by their whiteness the delicate green of the foliage, act as a centre-piece for the undifferentiated mass of colour and are of a happy significance. The two large jars in Plate XXIII, fig. 2, have a singularly restful effect. In Plate XXVII, fig. 1, is shown an old cannon used as ornament. Here perhaps (so protean is art) the contrast enhances its value. Doubtless the ancientness of the gun and the suggestions that go with it, make it suitable for decoration. Quaint Japanese lanterns are in many gardens not out of place (Plate XXVII, fig. 2).

The genius of the place, however, should be considered when planting a garden. A Japanese garden laboriously executed on the side of a wild hill in the Western Ghats is an offence to good taste. To the garden-lover each place offers its peculiar opportunity for appropriate design. The writers would draw attention to the spirit and method of Indian gardening design as described by Villiers Stuart in "Gardens of the Great Mughals." Those who believe that no garden can be artistically laid out in straight lines will receive enlightenment on perusing this charming work.

Such, then, are a few of the principles which we believe should be the foundation of ornamental gardening in India.

THE DEVELOPMENT OF AGRICULTURE IN ENGLAND.*

BY

D. CLOUSTON, M.A., B.Sc.,

Deputy Director of Agriculture, Southern and Western Circles, Central Provinces.

An account of the development of agriculture in England should be of the very greatest interest to us in India; because the development of Indian agriculture should proceed, and is proceeding, on the lines which have proved so successful in the West.

Going back to the Middle Ages we find that land in England was farmed by village communities grouped together for self-defence, under the lord of the manor who, as a rule, had his own home farm cultivated for him by the village peasantry, working under more or less servile conditions. Labour service was enforced: the village peasant was a kind of tenant-labourer who cultivated his own land, and gave such labour service as was required of him by his lord and master.

The village area was made up of (1) arable land, (2) a common grazing ground, and (3) waste lands. The arable land was divided up into small strips or fields. The several strips or fields of each farmer were scattered and hopelessly intermixed with those of his neighbours.

On the common village grazing ground disease was nearly always rampant. There cattle and sheep, tended by herdsmen common to the whole village, died by the hundred, as segregation was as impossible as it is in villages in India to-day, where this same objectionable system of having a common grazing ground still prevails.

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This system of landholding known as the open-field system blocked progress in English agriculture from the Middle Ages till the nineteenth century. The cultivation of turnips, clover, and artificial grasses which in the long run helped to revolutionize farming in England, was introduced in the seventeenth century; but the introduction of these crops made but little headway for over a century; because such crops could only be grown in enclosed villages, that is to say, in villages in which the land had been re-distributed so as to give each farmer a consolidated area which he could fence round. In open-field villages where the whole arable area was thrown open to grazing without let or hindrance, from the harvest time till sowing time, *i.e.*, from August till March, crops like turnips, clover, and artificial grasses would have been eaten during the winter by the half-starved village flocks and herds.

This open-field system gave way slowly under economic pressure. The fourteenth century was a particularly trying one for English farmers. War with France, the Black Death and a series of bad years all combined in that century to bring farming to a low ebb. The Black Death alone is said to have wiped out nearly one-half of the rural population between 1348 and 1350. Much land was allowed to go out of cultivation in consequence for want of tenants and labour. The tenant-labourer was no longer willing to work under the old conditions. He preferred to leave his self-contained village where money was scarce, to try his fortune in the more civilized industrial centres, where wealth, freedom, and comfort were more in evidence. Landlords had, therefore, to adapt themselves to the times by consolidating large areas which they put under pasture land for sheep. This branch of husbandry paid well and required but little labour. The great boom in the wool trade in the fifteenth and sixteenth centuries still further encouraged this.

The period dating from about 1780 till 1815 was one of great prosperity for English farmers. The rapid development of our great manufacturing industries and the Napoleonic wars which took place within this period had forced up the prices of grain and meat to exorbitant figures. It paid both landlords and tenants

under these circumstances to enlarge and enclose their farms. This Government encouraged as it led to more intensive farming and to a greater production of food-stuffs at a time when starvation threatened the land. The introduction at this time of clover, artificial grasses, and root crops in enclosed villages enabled farmers to keep more and better live stock.

' This brings us up to 1815. There was as yet no science of agriculture. The methods of the best practical men were empirical. Of agricultural writers there had been many from the sixteenth century onwards ; but it was largely a case of the blind trying to lead the blind. I use the term trying, because as a matter of fact these writers were contemptuously spoken of as book-farmers and quacks by the farmers of their time and their writings were sneered at.

This is not to be wondered at when we consider the qualifications of these would-be agricultural advisers. One of them, for instance, who wrote in the seventeenth century, advised farmers to breed elephants, which he described as " the greatest, wisest, and longest-lived of all beasts." Donaldson of the same century, who was the first writer on agricultural subjects in Scotland, admitted that he took to writing books because he had failed as a practical farmer. In the preface to his book on " Improved Husbandry," he says that he feared that his ideas on farming would be regarded " as fool's notions, and that his readers would say that he himself had a bee in his bonnet."

Still it is a hopeful sign when we find practical farmers lamenting the want of facilities for experimental work in improved farming as they were beginning to do in the seventeenth century.

In the latter half of the eighteenth century Jethro Tull, Robert Bakewell, Lord Townshend, and Arthur Young did much for the improvement of farming in England. They had travelled in the Low Countries and France, and had seen for themselves that excellent cereal crops were being grown in those countries in rotation with clover, grasses, and root crops. They saw, moreover, that in these countries where agriculture was much more advanced than in

England, crops were sown in lines and hoed by means of implements specially designed for that purpose. They also learned that by rotating cereal crops with root crops, clover, and grasses, it was not necessary to let the land lie fallow at intervals of three or four years as was commonly done in England. This and much other useful information they carried back and turned to good account on their own farms.

Farming in England was still in a very backward state at this time. The few implements used were of the most primitive kind. The plough was a clumsy wooden implement with an iron point or share ; it was drawn by three or four pairs of bullocks. Large clods turned up by it were broken by hand or by drawing a wooden beam over the land. Crops were sown broadcast and harvested with small sickles. In the absence of any root crop and of implements for interculture land became foul with weeds. The use of artificial fertilizers was not yet known, and most of the cattle-manure was used as fuel as is done in India to-day. The out-turn of wheat per acre was less than half that obtained at the present day. Cattle were starved for want of proper stall-feeding, as the cultivation of clover and root crops had not yet been introduced to any great extent.

Such progress as was made in introducing improvements during this period dating from 1780 till 1815, can be traced to the interest taken in agriculture by the leaders of the people. Reference has already been made to the good work done by Jethro Tull, Bakewell, Lord Townshend, and Arthur Young, themselves gentleman-farmers. Lord Townshend farmed his own estate in Norfolk after retiring from political life. He it was who first introduced that four-year rotation of crops—turnips, barley, clover, and wheat—on his own estate in Norfolk. Jethro Tull showed English farmers how to sow their crops in lines and how to hoe them later by means of implements after the Dutch fashion. King George III, or Farmer George as he was called, said that he owed more to Jethro Tull for the introduction of this and other improvements than to any other man in his dominions. The King himself was a keen farmer and had started his own experimental farm at Windsor.

The Duke of Bedford about the same time opened an experimental farm on his estate at Woburn.

Our Rajas and other big landowners in India have much to learn from this page in the history of agricultural development in England.

But it was not till the middle of the nineteenth century that science began to be applied to any great extent to the development of the agricultural resources of England. Within the last 70 years chemists, geologists, botanists, physiologists, zoologists, entomologists, bacteriologists, engineers, architects, and mechanics have, by research work in the laboratory and experimental work in the field, built up the science of agriculture as we know it to-day. The farmer henceforth was to be guided by a band of specialists, each an expert in his own subject. During this period the nutritive value of cakes and other food-stuffs and the manurial value of artificial and other manures, was thoroughly worked out, and large quantities of the different available foods and manures are now being used by every farmer of any standing at home. Labour-saving machinery was introduced all round, and the farmer's labour bill reduced thereby to a mere fraction of what it used to be. Veterinary skill reduced mortality in farm stock. Commodious and comfortable farm-buildings replaced tumble-down steadings. Wet lands below the margin of cultivation were drained and made to give bumper crops.

Science alone could not have done all this in so short a time. The country required agencies whereby the practical results of the scientist could be brought to the notice of the actual farmer. This has been done by agricultural co-operation, education, and demonstration carried out by the Department of Agriculture. Agricultural colleges were opened and young men were trained in agricultural theory and research. County lecturers in agriculture were appointed and classes for training the sons and daughters of farmers in special branches of husbandry, such as dairying, stock-breeding, and poultry-management were started. Education in rural schools was remodelled with a view to interesting the child in his natural surroundings. He was taught how to use his hands and eyes,

and to become resourceful. Education in rural schools in short was made much more practical and less literary.

Agricultural co-operation was also pushed to the great advantage more especially of the smaller farmers, in so far as it has enabled them to get better prices for their farm produce.

All these improvements have helped to make the English farmer what he is to-day—enterprising, self-reliant, and resourceful. He has had his spells of bad times within recent years, but science and training have given him the power to adapt himself to changing conditions. When the price of wheat is low he takes up some other branch of farming that pays better.

This short review of the development of farming in England will help us to understand the agricultural problems we are up against in India to-day. History repeats itself; for here, in India, progress has been retarded for centuries by the open-field system of land-holding which was the bane of English farming for so long. But here, too, we hear its disadvantages deplored by the more enterprising landholders who fully realize that the open-field system in their villages handicaps the introduction of urgent agricultural improvements. The feasibility of re-striping and consolidating holdings is already being seriously discussed in some parts of India, both by Government and the people. Here, too, we have had our cultivators groping in the darkness of ignorance for ages, guided by empirical rules handed down to them by their forefathers. But the new and scientific era of agriculture with all its economic possibilities has begun in India at last, just as surely as it began in England in the middle of last century.

ALKALI SOILS: SOME BIOCHEMICAL FACTORS IN THEIR RECLAMATION.*

BY

J. H. BARNES, B. Sc., F.I.C.,

Principal, Punjab Agricultural College, and Agricultural Chemist to the Punjab Department of Agriculture.

AND

BARKAT ALI, L. Ag.,

Research Assistant in Chemistry in the Punjab Agricultural College.

I. Introduction.

In the tropical and sub-tropical regions throughout the world where the rainfall is less in amount than the water lost by evaporation from the surface of the soil we find in the low-lying lands a type of barren soil which owes its infertility to the presence of saline matter. This saline matter has its origin in the soil and is produced as a result of the combined action of water and carbon dioxide on the rock minerals from which the soil was formed. The result of these chemical actions is the production of carbonates, chlorides and sulphates of the alkali metals and alkaline earths, more especially of sodium, calcium and magnesium. Under favourable conditions of rainfall and drainage, these salts find their way into the seas and oceans where concentration by evaporation of the water gradually tends to increased salinity of the residue. This is particularly marked in the inland seas and large lakes such as the Dead Sea, Caspian Sea and the Salt Lake in Utah.

* A paper read at the Fourth Indian Science Congress, Bangalore, 1917.

Where the rate of water evaporation in the soil is greater than the rainfall, this saline matter increases in amount and remains in the soil sinking with each flush of rain only to reappear in increased amounts when the water is drawn to the surface by the combined forces of the sun's energy and the molecular force of surface tension. In some cases the amount of saline matter may be so large as to render a whole tract of country entirely white with a deposit of salt which is often some inches thick. More often, however, the saline matter indicates its presence by a fluffy appearance of the surface with a white incrustation of salt on the ridges of the land in the case of *white alkali* and by a brown intensely hard surface with a rusty brown saline efflorescence after the soil has been wetted in the case of *black alkali*.

The essential difference between these two types is the presence of sodium carbonate in the latter resulting from the decomposition of organic matter in the presence of alkaline sulphates. In either case the soil is destitute of vegetation unless the amount of alkali is small when certain hardy species such as the *Sálsolacea* manage to exist. As the amount of saline matter diminishes the soil shows a corresponding increased fertility, and the crops which can be grown on the border land lying between good soil and saline barren soil vary with the salinity. Thus, for example, barley, wheat and the *Cruciferæ* are more hardy than maize.

A considerable amount of time has been devoted in America to the study of the relative immunity of different crops to the various salts which are found in saline soils. The value of the results obtained is out of all proportion to the time or energy devoted to their acquisition—they have failed to prove useful and practical for want of a better knowledge of the scientific principles of the causes of sterility. If such causes had been first investigated time and money would have been saved and in the end the *practical* result would, as it always does, justify the scientist.

From our own observations we conclude that the salts present in alkali soils do not exert any toxic effect on the plant. The effects produced are purely physical. It is not the quantity of salt as such which is the important point, and it is for this reason that ordinary

chemical analysis is of itself almost valueless in the examination of such soils for the practical end of determining their suitability for plant growth. A table showing the tolerance of various crops to varying amounts of the salts commonly found in saline soils is of very limited value for the reason that the concentration of the aqueous solution of salts in the soil is constantly varying, and varying over very wide limits, and it is impossible to foretell from any chemical analysis what the degree of concentration will be—say, on the day following the analysis—because we cannot foresee what amount of water will be lost by evaporation in the meantime. It would be equally difficult to deduce from the same data what amount of water would have to be added so to reduce the concentration that germination or the normal growth of mature plants could proceed.

The danger point is reached when the osmotic pressure of the saline solution becomes equal to that of the cell sap. This is irrespective of the nature of the salt provided it possesses no toxic properties ; such salts as the sulphates and chlorides of sodium or calcium exhibit no toxicity to plant protoplasm. Even carbonate of soda cannot be said to be toxic in the present state of our knowledge though we know that it shows evidence of caustic action on the stems of plants growing in soils affected by the salt—whether the caustic effect is produced on dead or living tissues is not known. But as soon as the osmotic pressure of the fluid entering the root tips from the soil becomes greater than that of the cell sap, the protoplasm of the cell shrinks away from the containing walls and the plant loses its turgidity and becomes flaccid. It shows in fact all the appearance of withering and if the concentration of the external fluid is not immediately reduced by dilution, the plant dies. Dilution of the saline solution is in itself a remedy at this stage, and this is one reason which leads us to believe that the salts possess no toxic properties and that their effect is a purely physical phenomenon.

The reclamation of alkali soils for culturable purposes obviously involves the removal of the excess of saline matter by washing and drainage. But such soils not only contain useless saline matter in excess but the very causes which have led to their accumulation

have also resulted in the collection of salts of the highest importance to the fertility of the soil, such as soluble phosphates and potash salts. Washing and draining must therefore be done circumspectly lest we push the process too far and squander the soil riches lying ready to our hand. Clearly we only desire to carry the washing process to such a point that even with the driest soil conditions which will afterwards exist under cultivation, the concentration of saline matter in the soil water shall be such as to have a lower osmotic pressure than that of the cell sap.

The problem before us is how this point can be observed. It cannot be ascertained by chemical analysis and every chemist here will understand the enormous difficulty lying in the way of a laboratory determination of the osmotic pressure of a mixed salt solution and of realizing the results in the field. The growing plant will give us an index by plasmolysis but its use is lengthy, cumbersome and expensive—we may waste several lots of seed and more than one growing season in attempting to hit off this point of maximum fertility by a biological test involving the use of the crop itself.

There are, however, other plants present in the soil, namely, the soil bacteria which possess none of these disadvantages. They involve no outlay on seed, their rate of reproduction is so rapid and so under control in the laboratory that their use can rank of equal value with a physical determination of the actual osmotic pressure. They are subject to the same physical laws of molecular pressure in solution as the higher plants or the dead membrane of the physicist's instrument, and they possess the additional value and importance of being essential to soil fertility. In the following pages we shall proceed to show you a few of the results obtained in a line of studies which has now been followed for some three years past and which have preceded and run parallel with a reclamation experiment on a large scale in which we have at the same time worked out the economics of a system of fertilizing sterile salt lands with machinery and water—a system which has given the best possible financial results and promises a return of between 300 and 400 per cent. on the capital outlay. You will of course understand

that the time at our disposal in this Congress is too limited to allow of a full description of either the biological or chemical studies of saline salts which we have carried out at Lyallpur or of the reclamation experiment at Narwálá. These results will be published in detail in a series of papers in the Memoirs of the Indian Department of Agriculture. The tabulated results given below are some of those obtained from the Narwálá Farm soils. This farm which was leased for the reclamation experiment is situated in the Lower Chenab Canal Colony in the Lyallpur District and about 12 miles from Lyallpur. It is 139 acres in extent and of the whole area 47·9 acres were barren at the outset of the experiment. The soils of the farm varied considerably in the amount of saline matter they contained as will be seen from the following Table I. These figures do not represent *constant* composition but merely indicate the limits observed at various times in different fields on the farm.

TABLE I.

Composition of Narwálá soil in parts per 100.

	Soluble in water	Alkalinity as Na_2CO_3	Total chloride as NaCl	Calcium as CaO (Lime)	Alkali metals as chlorides	Sulphur as SO_3
Lowest	0·488	0·078	0·146	0·1700	0·15	0·100
Highest	4·408	0·954	1·287	0·9828	1·17	1·446

The sterile areas on this farm vary from barren patches a few yards in extent to whole fields of many acres.

In the following figures we shall refer to soil samples from the smaller areas or patches as *sterile patches* and to those from the larger areas as *salt land* samples.

II. BIOCHEMICAL METHODS ADOPTED.

The inhibition of bacterial growth by plasmolysis due to increased concentration of the saline soil water could be directly determined by plate counts if we could depend upon the bacteria being subject to no other vicissitudes. Unfortunately, however, the variations which take place in the temperature, moisture and air conditions of the soil, cause such enormous differences



NARWALA FARM BEFORE RECLAMATION.

Square 16, Fields 1, 2, 3, and 21, 22 and 23, showing general appearance of the saline character of the soil with dry salt-loving plants growing here and there. March 1914.



NARWALA FARM BEFORE RECLAMATION.

Square 3. Showing general view of the more fertile portions and the appearance of a sterile patch, March 1914.

in the number of bacteria as indicated by plate count that this method has long been recognized as worthless in forming an opinion of the fertility of the soil in respect of its nitrifying or ammonifying power (*Cf.* Remy, *Cent. f. Bakt.*, 1912; Löhnis, *ibid*, 1904; Hutchinson, *Memoirs of the Department of Agriculture in India, Bact. Series*, Vol. I, No. 1). The method adopted therefore is not to attempt a count of the organisms present but to measure their chemical activity under standard conditions. This involves the measurement of the rate of carbon dioxide formation, the rate of nitrification of ammonia both in a nutrient solution and in the soil and the rate of nitrogen fixation. The figures so obtained will give us an index to the number and condition of the bacteria responsible for these important processes or will in other words be an indirect measure of the decrease in the osmotic pressure of the soil water—using for the test not merely one type of organism but all those responsible for the three chief chemical reactions necessary to the full fertility of the soil.

(1) *Carbon dioxide formation.*

The method used is a modification of that suggested by Mr. C. M. Hutchinson (*loc. cit.*). To the soil is added 1 per cent. of oil-free *sarson** cake and an amount of water equivalent to a 30 per cent. saturation and the mixture incubated in a Woulff's bottle at 25° to 30° C. Every 24 hours the gaseous contents of the bottle are removed by air aspiration—the issuing gases being passed through standard baryta water to absorb the carbon dioxide. The amount of baryta remaining unchanged at the end of the experiment is determined by titration with standard hydrochloric acid and phenolphthalein. The rate of CO_2 evolution is a direct measure of the number and activity of the soil bacteria taken as a whole and since these are directly proportional to each other, that is to say, increasing numbers mean increased activity and *vice versâ*, the rate of CO_2 formation may be said to represent the equivalent of a plate count. By standardizing the condition of the experiment, that is, making moisture and temperature conditions equal or equivalent we can

* Indian colza (*Brassica campestris* var. *Sarson*).

draw an almost exact comparison between two soils, or the same soil before and after treatment.

(2) *Nitrification.*

This falls under two heads:—

(*a*) The nitrification which takes place in Oméliansky's solution after inoculation with soil emulsion and incubation at 30° to 35° C. and measured weekly.

(*b*) Nitrification in a soil medium.

In (*a*) 50 cc. of Oméliansky's solution are inoculated with 1 cc. of a 100 per cent. soil emulsion, 0·5 grm. of calcium carbonate added and incubated at from 30° to 35° C. in an Erlenmeyer flask. An estimation is made weekly of the amount of nitrous and nitric acid produced as a result of the bacterial activity.

For the estimation of nitrous nitrogen the Ilosvay's modification of Griess' method is used. This method depends upon the fact that an acetic acid solution of naphthylamine and sulphanilic acid gives a distinct red coloration after a short time in the presence of extremely small quantities of nitrous acid. The sulphanilic acid is converted by the nitrous acid into the corresponding diazo compound and the latter reacts with this and naphthylamine to form a red azo dye. The presence of 0·001 mg. of nitrous acid per litre can be detected within one minute of mixing.

The phenol-sulphonic acid method is used for the estimation of the nitric acid when analysing the products from Omélianský's solution. This method is not satisfactory in examining soil extracts, so in dealing with soil media the nitric acid is determined by reduction with zinc dust and reduced iron in the presence of strong sodium hydroxide, the resulting ammonia being distilled off and estimated by titration.

The wet method in Omélianský's solution is useful for soils in which the bacteria exist but are inhibited from showing activity on account of their surroundings in the soil itself. Their transfer to this nutrient solution places them in an ideal medium for growth.

(*b*) *Nitrification in a soil medium.* In this method 1 per cent. of oil-free *sarson* cake is added to the soil together with a requisite

amount of moisture (30 per cent. of the amount required for saturation) and incubated at 30° to 35° C.—this temperature having been found the best for Punjab nitrifying organisms. In the reaction which follows the organic nitrogen is converted first into ammonia, then into nitrites and finally into nitrates, which are estimated in the usual manner—ammonia by distillation and titration, nitrous acid and nitric acid by the Griess-Ilosvay and phenol-sulphonic and zinc-iron reduction methods, respectively.

The figures obtained for the rate of nitrification in the soil medium are exceedingly useful, because in this method we have field conditions with this difference that we have eliminated the changes which are incident there from differences of temperature, moisture and the physical defects of the soil.

(3) *Rate of nitrogen fixation by Azotobacter using mannite solution.*

The third type of bacterial activity measured is the ratio of nitrogen fixation by *Azotobacter chroococcum*, a large strongly aerobic bacterium which is held to be mainly responsible for the fixation of atmospheric nitrogen in the soil. In this method Ashby's nutrient solution is used (*Journal of Agricultural Science*, Vol. II, page 38), 50 cc. being taken for the experiment instead of 100 cc., 0·5 grm. of calcium carbonate is added and the contents of the flask sterilized. The nutrient is then inoculated with one grm. of soil in the form of soil emulsion 100 per cent. and incubated at 30°C. for ten to fourteen days. The contents of the flask are then transferred to a Kjeldahl flask and the nitrogen estimated by the Kjeldahl-Gunning method. A blank experiment is done with the addition of sterile soil to provide a check on the nitrogen contents of the materials constituting the nutrient as well as the nitrogen contents of the soil itself at the outset of the experiment.

With these methods we will proceed to make an examination of the changes which take place when saline soils are washed. In the following series of experiments, samples of soils drawn from the smaller "sterile patches" or the larger "salt lands" were examined before and after washing with distilled water in the

laboratory—the wash water being decanted off after allowing the soil to settle for some time. The soil was then air dried and subjected to the above biochemical tests.

From the figures given in Table II, we can see that *salt land* soil is evidently a very unfavourable medium for general bacterial activity. Secondly, that the biochemical activity of the soil in the *stèrile patch* is greater than that of the *salt land* but less than a normal soil. Thirdly, and of great importance is the great revival of biochemical activity in the soil of the *salt land* sample *after washing with water*, the amount of CO_2 given out from the washed soil being 36 times that given out from the unwashed samples of the same soil. It is also greater than that of normal soil, thus indicating the richness of the soil after washing.

TABLE II.

Showing the milligrams of CO_2 *given out from* 200 *grm. of Narwálá soil.*

(Oil-free cake added is equal to 1 *per cent.)*

Duration of the Experiment	Salt land	*Washed salt land*	Sterile patch	Normal Soil
After 1 day	2·60	**36·8**	8·5	31·2
„ 2 days	1·80	**69·6**	22·0	37·9
„ 3 „	2·40	**71·6**	14·9	30·3
„ 4 „	1·30	**80·0**	27·2	67·3
„ 5 „	2·20	**95·4**	32·1	74·5
„ 6 „	1·10	**98·0**	57·2	94·3
„ 7 „	1·20	**88·8**	48·0	74·8
„ 8 „	1·40	**81·4**	45·1	42·8
„ 9 „	1 60	**59·8**	42·9	62·7
„ 10 „	1·40	**40·8**	40·0	45·1
„ 11 „	0·55	**31·6**	32·1	40·2
„ 12 „	1 20	**27·2**	25·9	25·9
„ 13 „	1·50	**22·0**	29·0	22·8
„ 14 „	1·40	**18·2**	28·8	18·2
„ 15 „	1·60	**18·2**	27·7	16·0
Total ..	23·25	**839·4**	481·4	684·0

This enormous increase in the biochemical activity of a barren saline soil after washing with distilled water indicates that the organisms which are responsible for CO_2 production are dormant

in the presence of excess of saline matter and the increase in activity as measured by CO_2 production after washing tells us that it is the saline matter which renders the organisms inactive. While the saline matter is in excess, that is while the soil moisture has an osmotic pressure higher than that of the protoplasm of the bacteria, these organisms remain dormant or are killed off altogether. The rapid development, which takes place after washing, indicates that the organisms at Narwálá are not dead, but only dormant, for the CO_2 production from a washed soil exceeds that from a normal soil within 24 hours of the addition of the oil-cake. This experiment provides us with yet another proof that the salts present in alkali soils are not toxic and the barrenness of the soils is due to the physical effect of excessive solution pressure. The next reaction measured is the amount of nitrification of a dilute solution of ammonium sulphate (Oméliansky's solution). This is shown in Table III.

The figures so obtained give us the following results :—

(*i*) Just as in the case of CO_2 formation, the nitrifying organisms are present in the soil but are dormant so long as the saline matter is in excess.

(*ii*) In the sterile patch, the soil is less saline than that in the salt land but is still too heavily impregnated with salt to admit of ordinary crops growing in it; yet the nitrifying organisms are in full activity.

(*iii*) We therefore arrive at the interesting deduction that nitrifying organisms are comparatively hardy as regards the presence of saline matter and can exist in a solution of higher osmotic pressure than can the higher plants. Washing of these soils will, therefore, be followed by increased nitrification and this increase will begin some time before the soil is sufficiently washed to admit of the cultivation and growth of farm crops.

We will now see how far these figures are borne out when we measure the ammonification and nitrification which takes place in the soil itself. The experiment is done under laboratory conditions so as to exercise control over the temperature, moisture and

TABLE III.

Milligrams of Nitrous and Nitric Nitrogen produced by 1 grm. of Soil in 100 cc. dilute Oméliansky's solution.

Soil	Original		After one week		After two weeks		After three weeks		After four weeks		After five weeks		After eight weeks	
	Nitrous N	Nitric N	Nitrous N	Nitric N	Nitrous N	Nitric N	Nitrous N	Nitric N	Nitrous N	Nitric N	Nitrous N	Nitric N	Nitrous N	Nitric N
Salt land ..	nil	**0·24**	nil	**0·25**	**0·17**	**0·35**	**1·64**	**0·4**	**5·48**	**0·9**	**2·4**	**1·2**	**0·07**	**5·6**
Sterile patch ..	nil	0·40	0·04	0·50	2·88	0·80	2·05	0·9	1·92	3·2	nil	4·8	not done	not done
Normal soil ..	nil	nil	0·07	nil	1·58	0·60	1·51	0·8	nil	4·6	nil	6·0	not done	not done

food conditions. In addition to examining the effect of washing some saline soil, we will also see to what extent the nitrification and ammonification will be effected in a washed saline soil when afterwards inoculated with normal soil. This will give us a comparison with actual field conditions in which we shall wash the land with canal water. The results obtained are given in Table IV.

These results indicate that :—

(*i*) *Under field conditions* which are very different from those existing in an ideal medium such as Oméliansky's solution, the nitrifying organisms in both the *sterile patch* and in *salt land* are inactive, no increase in nitric nitrogen having taken place in five weeks.

(*ii*) On the other hand, *salt land* soil after washing shows an increased nitrification amounting to nearly 900 per cent. in five weeks.

(*iii*) Saline soil washed with distilled water and afterwards inoculated with normal soil shows an increased nitrification of 1,600 per cent. after the same period.

(*iv*) We may certainly rely on improved nitrification following on the washing of such saline soil with canal water.

(*v*) In the less saline conditions such as exist in *sterile patches*, the organisms responsible for ammonification appear more active at the end of the fifth week than in either normal, sterile or washed soils. This is not so in reality. What has taken place is that ammonification has proceeded with greater rapidity in the sterile patch than in the *salt land* washed or unwashed but with less rapidity than that of the normal soil. This is because the organisms responsible for oxidation of the ammonia are less active in saline solution than the ammonifying organism. This suggestion receives confirmation from Table II where the oxidation factor as measured by the rate of CO_2 production is much less than that of normal or washed soils.

(*vi*) From (*v*) it follows that the ammonification organisms are more hardy to saline matter than the nitrifying

TABLE IV.

Milligrams of Ammonia, Nitrous and Nitric Nitrogen produced by 100 *grm. of Narwâlâ soil* (T = 30°C., *moisture* = 30 *per cent. of saturation capacity and* 1 *grm. of oil-free cake added*).

Soil.	Original			After one week			After two weeks			After three weeks			After five weeks		
	Ammonia N	Nitrous N	Nitric N	Ammonia N	Nitrous N	Nitric N	Ammonia N	Nitrous N	Nitric N	Ammonia N	Nitrous N	Nitric N	Ammonia N	Nitrous N	Nitric N
Normal soil ..	1·90	nil	nil	28·0	0·40	1·68	27·44	1·37	1·71	20·58	4·66	7·38	6·51	2·19	22·47
Sterile patch ..	2·16	nil	43·75	15·4	0·28	40·68	21·44	trace	15·26	26·46	0·03	42·25	25·41	nil	42·84
Salt land ..	**1·30**	nil	**24·08**	**2·0**	nil	**22·12**	**1·86**	**0·13**	**23·94**	**4·20**	**0·19**	**23·33**	**6·93**	**0·11**	**24·81**
Washed salt land	**2·52**	**0·41**	**0·71**	not done	not done	not done	**28·98**	**0·16**	**1·52**	**23·18**	**3·01**	**5·24**	**3·36**	**16·46**	**6·78**
Washed salt land to which emulsion from normal soil has been added.	**2·70**	**0·41**	**0·71**	not done	not done	not done	**28·14**	**0·01**	**1·11**	**26·54**	**0·04**	**5·00**	**4·20**	**9·97**	**11·87**



NARWALA FARM. FIRST YEAR AFTER RECLAMATION.
SQUARE 3, FIELD 4. WHEAT. March 1915.



NARWALA FARM. FIRST YEAR AFTER RECLAMATION.
SQUARE 16, FIELD 5. BARLEY. Mach 1915.

organisms or if the same organisms can carry out the two processes of reduction and oxidation then the *reductase* enzyme is more resistant to salt than the *oxidase* enzyme.

Experimenting on similar lines with nitrogen fixation by *Azotobacter chroococcum,* we found the relative amounts of nitrogen fixed per grm. of mannite solution employed were as follows :—

	Mg. of nitrogen fixed by 1 grm. of soil with 1 grm. of mannite
Salt land	1·23
Sterile patch	7·80
Normal soil	7·07

Evidently then this organism possesses high resistive power to salt, or the osmotic pressure of its protoplasm is high as compared with nitrifying and oxidizing organisms. This is important because it indicates that nitrogen fixation will commence at an early stage of the washing process provided we supply the organisms with air and organic food.

Intermittent washing combined with the ploughing in of any weeds or other organic refuse will therefore prove beneficial.

Summarizing these preliminary tests, we see that ordinary alkali soils contain all the organic life associated with soil fertility, but in a more or less dormant state. The vitality of these organisms is somewhat impaired in the more saline soils of long duration. In salt land of recent origin and lower saline contents such as the *sterile patch,* the organisms, though inactive in some of their reaction, are unimpaired in vitality. These results are of the highest importance and give promise of success on a field scale.

We will now proceed to give a few of the figures obtained from the Narwálá Farm soils during the course of the reclamation.

In the following table (Table V) is given the rate of CO_2 formation, using for the test a number of samples of soils from different fields before and after washing and draining. A very marked improvement is noticeable. All the soils were saline and barren to commence with and the first washing resulted in an almost complete reclamation of the land, the barren land as tested by wheat being

TABLE V.

Comparison of CO_2 formation between washed and unwashed barren soil at Naruálá. Milligrams of CO_2 from 200 grm. of soil.

Soil	After 1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	9th day	10th day	11th day	12th day	13th day	14th day	15th day	TOTAL
Typical barren soil ..	**2·60**	**1·76**	**2·40**	**1·32**	**2·20**	**1·10**	**1·20**	**1·43**	**1·65**	**1·43**	**0·55**	**1·20**	**1·54**	**1·43**	**1·65**	**23·4**
No. 1.—Normal soil, Sq. 2, Field 5	10·78	23·43	100·32	85·58	54·34	62·70	55·12	55·12	63·80	39·82	40·48	41·60	35·42	29·26	25·74	723·5
No. 11.—Sterile patch, Sq. 2, Field 5	3·30	13·86	35·30	42·90	25·30	30·58	22·20	35·20	47·52	46·42	46·62	41·80	45·54	41·58	37·62	515·7
No. 2.—Normal soil, Sq. 2, Field 5	8·14	68·36	99·88	80·30	78·54	66·00	79·66	83·16	81·84	77·44	49·28	44·00	41·00	34·86	30·36	922·8
No. 21.—Sterile patch, Sq. 2, Field 5	2·64	12·10	30·14	44·44	26·18	25·08	32·12	35·42	43·78	43·12	36·08	40·70	38·60	32·56	32·56	475·5
No. 3.—Normal soil, Sq. 3. Field 2	5·72	44·66	92·62	79·20	68·64	66·44	75·90	63·80	65·56	51·92	52·36	42·24	48·62	39·38	30·52	827·6
No. 31.—Sterile patch. Sq. 3, Field 3	2·64	23·32	49·94	40·92	22·88	24·20	33·88	39·16	50·82	50·82	44·88	50·16	38·06	33·22	36·99	541·9



NARWALA FARM. FIRST YEAR AFTER RECLAMATION.

Square 19, Field 4. Maize. Showing the characteristic delicacy of Maize which is far less tolerant to saline matter than wheat. This same field carried a 20 maunds crop of wheat.



NARWALA FARM. SECOND YEAR AFTER RECLAMATION.

SQUARE 18. FIELD 9. TORIA. November 1915.

reduced from 47·9 acres to 3·8 acres. Some barren patches still remained and the rate of CO_2 formation for some of these soils is given in Table V.

The figures of the above table show that improvement has been effected even in the patches which are still unable to bear a crop of wheat.

A second washing of the soils still barren after one washing was then done and the CO_2 formation again determined. The figures so obtained are given in Table VI.

TABLE VI.

Milligrams of CO_2 evolved from 200 grm. of Narwálá soils

(*a*) The figures in plain type are of soils normal after second washing and were also such after first.

(*b*) The figures in heavy type are of soils normal after second washing but were still barren after first washing.

Day No.	Soil I	**Soil I**	Soil II	**Soil II**	Soil III	**Soil III**
After 1 day ..	77·0	**97·5**	65·1	**96·6**	77·0	**74·4**
,, 2 days ..	112·4	**139·7**	115·5	**133·5**	138·6	**130·5**
,, 3 ,, ..	127·4	**133·0**	143·2	**142·6**	151·4	**144·5**
,, 4 ,, ..	166·8	**166·5**	171·4	**183·5**	174·5	**166·5**
,, 5 ,, ..	132·8	**143·2**	168·5	**165·9**	141·9	**152·9**
,, 6 ,, ..	74·4	**91·8**	111·1	**98·8**	77·7	**75·0**
,, 7 ,, ..	46·4	**48·8**	59·4	**36·5**	51·5	**48·8**
Total ..	737·2	**820·0**	834·2	**857·4**	812·6	**792·6**

It is noticeable that fields which were barren after one washing have still further improved and after two washings are equal to ordinary normal soils. Cropping in the second year bore this out. It will also be seen that soils II and III—normal after the first washing—show a slight reduction in the amount of CO_2 produced after a second washing. This may probably be due to excessive washing of these areas.

We have now to consider the rate and amount of nitrification taking place in the field as measured by cultures in Omélianský's solution as well as bacterial cultures in a soil medium in the

laboratory. Table VII gives the results obtained in the first of these tests, *viz.*, the amount and rate of nitrification in Oméliansky's solution. The soil samples were drawn from fields in the second year of the experiment so as to show the full effect of washing. It is clear from these figures that an enormous improvement has been effected; the results obtained in the field bearing out the preliminary laboratory results. All the soils indicated in Table VII were bearing crops at the time of the test.

Turning now to the nitrification test in a soil medium, we will show how this demonstrates the difference existing in the field between a partially reclaimed soil and one which has been fully reclaimed and which is capable of bearing an ordinary farm crop.

In Table VIII is given the nitrification and ammonification test on five samples of soils drawn from different parts of the farm. All these soils were originally barren after one washing; one only of these soils indicated in the table was capable of growing a crop of wheat. This is the second sample in the table where it will be seen that nitrification has proceeded as far as the production of nitric acid.

In no other case given in this table has any nitric nitrogen been formed.

Such then is the nature of a partially reclaimed soil. It is very clear that increased bacterial activity has been induced as a result of the washing but this operation has not been carried to the point of success except in the one case quoted above. Further application of water resulted in restoring these soils to a condition of full fertility. The results obtained in this field test bear out the laboratory figures given in Table IV and the deductions drawn from them, *viz.*, that the organisms responsible for ammonification are more hardy to saline solutions than are those responsible for the oxidation of the ammonia.

Similarly a determination of the activity of nitrogen-fixing bacteria of the *Azotobacter* type indicates an increased activity after washing (*see* Table IX) and again bears out the laboratory results obtained in the preliminary enquiry.



TABLE VII.

Milligrams of Nitrous and Nitric Nitrogen per 100 cc. of dilute Omeliansky's solution from washed and unwashed soils.

Soil	Original		After one week		After two weeks		After three weeks		After four weeks	
	Nitrous N	Nitric N	Nitrous N	Nitric N	Nitrous N	Nitric N	Nitrous N	Nitric N	Nitrous N	Nitric N
Typical barren soil	**nil**	**0·245**	**nil**	**0·25**	**0·17**	**0·35**	**1·64**	**0·40**	**5·48**	**0·90**
Normal, Sq. 2, Field 5	nil	nil	1·25	nil	1·71	0·47	1·58	6·07	nil	8·93
Normal (sterile after first washing), Sq. 2, Field 5 ..	nil	nil	1·33	nil	3·33	0·40	1·46	6·40	nil	9·85
Normal, Sq. 3, Field 2	nil	nil	1·38	nil	2·67	0·87	nil	7·37	nil	9·46
Normal (sterile after first washing), Sq. 3, Field 3 ..	nil	nil	1·25	nil	1·65	1·62	nil	7·81	nil	9·27
Normal, Sq. 2, Field 7	nil	nil	2·76	nil	2·00	0·62	nil	7·37	nil	8·93
Normal (sterile after first washing), Sq. 2, Field 7 ..	nil	nil	1·91	nil	2·25	0·66	0·84	5·35	nil	9·27

Note.—" Normal " means, here, that these soils became normal after first washing.

TABLE VIII.

Milligrams of Nitrogen as Ammonia, Nitrite and Nitrate per 100 grm. of soil.

Soil	After one week			After two weeks			After three weeks			After four weeks		
	Ammonia N	Nitrous N	Nitric N	Ammonia N	Nitrous N	Nitric N	Ammonia N	Nitrous N	Nitric N	Ammonia N	Nitrous N	Nitric N
Typical barren soil	**0·7**	**0·00**	**0·00**	**0·56**	**0·13**	**0·00**	**2·90**	**0·19**	**0·00**	**4·26**	**0·10**	**0·00**
Normal soil, Sq. 3, Field 7	19·4	0·14	nil	18·30	0·88	nil	13·30	2·20	**10·60**	10·70	0·70	**16·9**
Sterile patch, Sq. 3, Field 7	20·5	0·17	nil	23·70	0·06	nil	20·72	0·06	nil	19·61	trace	nil
Sterile patch, Sq. 2, Field 3	17·1	trace	nil	21·50	0·03	nil	21·00	trace	nil	20·30	trace	nil
Sterile patch, Sq. 3, Field 2	18·3	trace	nil	23·30	nil	nil	21·40	trace	nil	19·60	trace	nil
Sterile patch, Sq. 2, Field 5	18·2	trace	nil	23·00	0·30	nil	22·20	0·06	nil	19·60	0·01	nil



NARWALA FARM. SECOND YEAR AFTER RECLAMATION
SQUARE 17. FIELD 6. COTTON, August 1916.



NARWALA FARM. SECOND YEAR AFTER RECLAMATION.
Square 16, Field 3. Maize. Showing completion of washing process for even the delicate crops. August 1916.

TABLE IX.

Milligrams of Nitrogen fixed from the air, per grm. of mannite.

Description of soil sample	Milligrams of Nitrogen fixed
Typical barren soil	**1·23**
Normal soil, Sq. 2, Field 2	7·50
Normal soil, Sq. 2, Field 2 (was sterile after one washing)	11·05
Normal soil, Sq. 2, Field 7	10·20
Normal soil, Sq. 2, Field 7 (was sterile after one washing)	11·80
Normal soil, Sq. 3, Field 2	11·85
Normal soil, Sq. 3, Field 3 (was sterile after one washing)	12·45

The out-turn of wheat (reckoned in maunds per acre) from some of these barren soils was extremely high and far in excess of anything obtained under ordinary *desi* cultivation. In the fields the examinations of whose soils are given in the above tables the yields were as follows:—

TABLE X.

Out-turn of wheat in maunds per acre obtained from reclaimed barren soils at Narwálá.

Field	Out-turn before washing	Out-turn after washing
Square 2, Field 2	nil	24·5
	nil	19·5
,, 3 ,, 2	nil	19·0
,, 3 ,, 3	nil	18.0

A more comprehensive statement of the yield of crop for the whole farm will be found in Table XI.

We have given no account of the researches on the cause and growth of alkali salts in the soils of North India—the senior writer's experiments in this connection will, it is hoped, be published shortly. Nor have we given any account of the experimental reclamation of land on a large scale, as this does not come within the scope of the paper. It suffices to say here that the Narwálá experiment has proved so successful and so remunerative that the Punjab Government are now considering a proposition to apply the methods of Narwálá to the reclamation of Crown lands in the Lower Bari Doab Canal on an extensive scale. If this can be done, it is estimated that the capital value of the land in this colony can be increased by upwards of 5 million sterling, probably over six millions, and at a cost which can be liquidated within five years of reclaiming the land. We have given but a few of the many figures collected in the biochemical reactions of these saline soils; still, few as they are, they suffice to show how valuable is this new weapon in attacking the problem of land reclamation. The use of the soil bacteria and the measurement of their activity provides us with a useful and quick method of obtaining equivalent valuation of the osmotic pressure of the soil solution. It eliminates the necessity for a lengthy and cumbersome chemical analysis and the measurement by physical methods of the osmotic pressure of the salts at varying dilutions which occur under field conditions. The information which such physical results would yield even when combined with extensive knowledge of the osmotic pressure of the sap of various plants at different stages of growth, would be so cumbersome as to require more than ordinary skill for the manipulation of the methods or the interpretation of the results. The biochemical method, on the other hand, is so simple that a chemist of but mediocre attainments and with an elementary knowledge of bacteriological technique can secure results of a high degree of accuracy because he is dealing with the collective activities of a large number of organisms and the error due to manipulation is correspondingly lessened. Instead of making a physical measurement of the osmotic pressure directly and interpreting the result, a method, which I have already said, presents great

TABLE XI.

Statement of yield of crops, Narwálá Farm, 1914-15 and 1915-16.

(Abstract from Report to the Punjab Government by J. H. Barnes, September, 1916.)

Particulars		Wheat	Barley	Barley and gram	*Bhusa*	Toria (*B. Napus* var. *dichotoma*)	Turnip and *senji**	Rice (un-husked)	Maize	Total
Area under crop in acres.	1914–15	86	5·93	..	..	..	3	..	..	95
	1915–16	42·76	..	12·09	..	33·87	8·5	8·7	9·8	116
Total yield in maunds and seers.	1914–15	1,597 19	118 6	..	Exact weight not known	..	Used as fodder	..	..	..
	1915–16	963 25	..	107 20	As above	331 26	As above	80 9	162 39	..
Yield per acre in maunds and seers. Highest	1914–15	26 20	25 12	..	..	..	..	..	..	..
	1915–16	37 31½	..	18 0	..	18 22	..	21 0	21 7½	..
Lowest	1914–15	13 18	18 14	..	..	..	..	..	..	..
	1915–16	15 16	..	6 15	..	7 6	..	6 7	13 36	..
Average	1914–15	(a) 18 23	(b) 19 33	(c) ..	..	(d) ..	..	(e) ..	(f) ..	..
	1915–16	22 21	..	8 35	..	9 32	..	9 9	16 25	..
Value in rupees, annas, and pies. 1914-15	Total ..	6,745 2 0	295 0 0	..	1,344 3 0	..	..	..	..	8,384 5 0
	Per acre	78 6 11	49 9 4	..	..	..	..	..	..	88 4 1
1915-16	Total ..	3,131 13 0	..	322 8 0	800 0 0	1,408 4 0	245 13 0	258 11 0	453 5 0	6,620 6 0
	Per acre	73 3 10	..	26 10 9	..	41 9 3	28 14 8	29 11 9	46 4 1	57 1 2

* *Melilotus indica. M. alba.*

(*a*) Out-turn good in 1914-15; very good in 1915-16.

(*b*) Out-turn on the whole good.

(*c*) Out-turn poor. This was due to the heavy washing of the fields in growing the rice crop, as the land has been deep cultivated, a lot of water had to be used for growing rice, since difficulty was experienced in puddling the soil. This was evidenced by the general poor appearance of the crop when growing. Gram and barley, which followed the rice, showed similar exhaustion of the soil. The washing had evidently been carried to the point of establishing uniformity in the mineral manurial constituents of the soil.

(*d*) The crop was a bumper one, but yields were below expectations on account of the Toria being beaten down by wind while in an immature condition.

(*e*) See (*c*).

(*f*) Out-turn on the whole good.

Comparing the two years, we see that excessive washing has lowered the crop-yielding value of some fields, *viz.*, those on which rice was grown, hence the lower out-turn for 1915-16. There is no reason to believe that the areas which were overwashed will not speedily recover their full fertility.

Toria did not do well because of the falling of the crop in an immature condition.

The high yields for wheat in 1915-16 show that the second washing of the land which was still *kalrathi* at the end of 1914-15 put this portion of the farm in first class condition.

difficulties—we make the same measurement indirectly by measuring the chemical activity of a very large number of organisms all of whose activities are regulated, restricted or enhanced by varying the osmotic pressure of the medium in which they are grown. It is the farm test method on a small scale—reduced to a laboratory test *in vitro* and with these additional points in its favour, *viz.*, it is *quick* and *cheap*.

You will perhaps ask why we have not given the chemical analysis of the soils mentioned in the above biochemical tests. We have specially avoided doing so lest the angle of vision of the student should be misdirected to again looking at these soils as barren because of the salt. They are barren because of the osmotic pressure of the soil water and the chemical type of the salt producing the pressure is, with the exception of sodium carbonate and magnesium salts, unimportant. The nature of the salt only becomes important when we begin to consider the relationship existing between the salt and its solvent and between the salt solution and the soil through which it is passing. These theoretical considerations and the practical issues on which they bear have no place here and for this reason any account of the composition of the salts in these soils has been avoided.

SOME OBSERVATIONS ON THE OCCURRENCE OF INFERTILITY UNDER TREES.*

BY

JATINDRA NATH SEN, M.A., F.C.S.,

Supernumerary Agricultural Chemist.

It is well known that trees often give rise to the formation of infertile patches around themselves. Some are so bad in this respect that the land near about becomes absolutely bare of vegetation. Grass refuses to grow under tamarind trees or near bamboo clumps. In case of other trees the lands near them, though not absolutely infertile, are found to be less productive than those further away.

People say that the phenomenon is due to shade (*chhaharhi*). This theory, however, does not wholly explain the phenomenon. In the first place the affected tract of land does not always coincide with the shade-limit. A glance at Plate XXXIII will indicate the effect of the bamboo avenue at the border of the N. Pangarbi field (in the Pusa Estate) on the growth of oats in the field. The clumps are surrounded by successive semi-circular patches. The growth of oats is seen to diminish gradually from the circumference of these patches on towards the clumps near which there is no germination. These patches, however, in no way coincide with the maximum shade-limits of the bamboos. Then again lands under bamboos are known to remain infertile even after the removal of the clumps—the source of obstruction of the sun's rays. The ryot has an aversion to cultivating *bans jami* (bamboo land) even when the trees are cut down. Interference with the rays of the sun cannot, therefore, sufficiently explain the phenomenon.

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* Received for publication on the 22nd February, 1917.

PLATE XXXIII.



EFFE OF BAMBOO AVENUE, PANGARBI ELD.

What then are the other factors which bring about the infertility? The question is too complicated for an offhand reply, nevertheless the results of certain observations made on this subject at Pusa are given below.

A sample of soil, one foot deep, was taken from under a tamarind tree. The layers in the upper six inches of the soil and those in the lower six inches were collected separately, parts of roots, etc., were removed, and then they were packed in their natural order in cultivation jars. A sample of soil from a grass plot was similarly treated and placed in another set of jars for comparison. A crop of maize was then grown in all the jars.

With a view to test whether, and if so to what extent, roots and fallen leaves of trees are responsible for the infertility, tamarind leaves and roots were separately added to the soils in some of the jars of each of the two sets.

The moisture content of the soils was maintained constant at 20 per cent.—an amount which has been found by actual experience to be the best for Pusa soils.

The appearance of the plants at the end of two months is shown in Plate XXXIV.[1]

All the plants in " tamarind soil " were very sickly, while those in " grass soil " were more vigorous, the average weight of these latter being above three-and-a-half times as much as that of the plants in the soil collected from under the tamarind tree. Addition of tamarind leaves and roots did not seem to have any appreciable influence on the growth of the plants.

It was thus obvious that the tamarind soil contained something which is positively harmful to the growth of crops. The soil is of a peculiarly loose texture. The feel is like that of the *nunia matti* (nitrous earth), the texture being what the *nunias*[2] call *phusphusi*. The sample of soil used in the above experiments contained soluble salts as is evidenced by the analysis in Table I.

[1] Jars Nos. 1- 6 were filled with soil from under a tamarind tree, while Nos. 7—12 contained soil from a grass plot. Tamarind leaves were added to the soil in Nos. 3, 4, 9, and 10. Tamarind roots were added to the soil in Nos. 5, 6, 11, and 12.

[2] A class of people who extract crude saltpetre from the naturally occurring nitrous earths.

Table I.

Soluble salts in the "Tamarind soil" used in the pot experiment.

	Surface soil 0″—6″	Sub-soil 6″—1′
Total salts per cent.	0·420	0·370
Calcium (Ca) per cent.	0·044	0·029
Magnesium (Mg) per cent.	0·012	0·016
Potassium (K) per cent.	0·033	0·015
Carbonic acid (CO_3) per cent.	0·015	0·013
Hydrochloric acid (Cl) per cent.	0·069	0·033
Sulphuric acid (SO_4) per cent.	0·072	0·158
Rate of percolation[1] cm. per hour	0·3465	0·3094

The trouble in this case was thus due to the soluble salts in the soil which are known to possess a harmful effect when present in such amounts.

It seems likely that other cases of such infertility might also be due to similar accumulations of soluble salts in the soil. As a matter of fact *usar* deposits are often visible to the eye in such places. Had the infertility been due mainly to an unequal competition between the tree and the crop for sunlight and the soil nutrients, in which the crop finds itself at a disadvantage, the removal of the tree would have remedied matters. It has, however, been observed that such a procedure often aggravates matters. There is after the removal of the trees at times an appearance of sterility where it previously did not exist or an increase in the extent of the unproductive region where the land was already infertile.

Such a phenomenon happened in the Botanical area at Pusa. Some *pipal*[2] trees were cut down about three years ago. Nothing abnormal was noted in the fields till last year when some infertile patches began to appear, and the sides of some of the drains (laid down under the Pusa system of drainage) were covered in places by *usar* crusts (Plate XXXV, fig. 1). These deposits were quite local, and when scraped out fresh crusts often formed again. The deposits appeared to be due to drainage from the infertile patches which usually occurred in those parts where roots of *pipal* trees had formerly been dug up.

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[1] Measured by Major Leather's method. [2] *Ficus religiosa.*



Fig. 1. GROWTH OF MAIZE.
Jars 1 and 2 are filled with soil taken from under a tamarind tree.
Jars 7 and 8 were filled with soil taken from a grass plot.

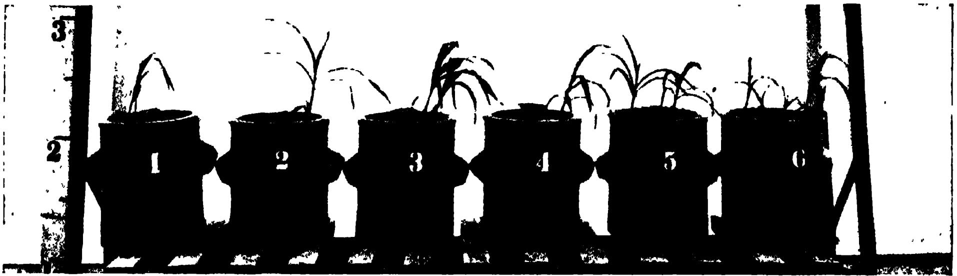


Fig. 2. GROWTH OF MAIZE.
All jars filled with soil from under a tamarind tree.
Tamarind leaves were added to the soil in Jars 3 and 4.
Tamarind roots were added to the soil in Jars 5 and 6.



Fig. 3. GROWTH OF MAIZE.
All jars filled with soil taken from a grass plot.
Tamarind leaves were added to Jars 9 and 10.
Tamarind roots were added to Jars 11 and 12.

A similar formation of *usar* patches was also noticed in another part of the Botanical area. A strip of land, on which there was previously a row of bamboos, has been brought under cultivation. Wherever the clumps stood the soils are sterile and are in some cases covered with saline deposits.[1]

The first sample was taken from an *usar* patch in a field near the river. There had been a tamarind and a *pipal* tree near by, which were since cut down. The different depths of the soil were analysed and found to contain no " black alkali " (sodium carbonate) but only " white alkali " (sodium sulphate). The amount of salts decreased with the depth. Enough chloride and sulphate were, however, present at the surface to stop germination. The rate of percolation of water through the soil is slow, thus showing that the soil was bad for agriculture. Table II shows the results of analysis.

TABLE II.

Soluble salts in the different layers of a soil from an infertile patch.

Depth	Rate of percolation, cm. per hour	Bicarbonates* per cent.	Carbonates* per cent.	Chlorides* per cent.	Sulphates* per cent.
0″—6″ ..	0·0825	0·021	nil	0·364	0·930
1′—1′ 6″ ..	0·0404	0·033	nil	0·064	0·143
2′—2′ 6″ ..	0·0360	0·069	nil	0·055	0·110
3′—3′ 6″ ..	0·0240	0·033	nil	0·046	0·122
4′—4′ 6″ ..	0·0272	0·041	nil	0·029	0·091
5′—5′ 6″ ..	0·0278	0·039	traces	0·025	0·058
6′—6′ 6″ ..	0·0189	0·047	traces	0·025	0·058

* Calculated as sodium salts.

The field from which the above sample was taken has a drain on the side facing the river Gandak. It was on the other side of the drain (*i.e.*, on the river bank) that the *pipal* and tamarind trees stood previously. Saline deposits were found in the drain also.

[1] The thanks of the writer are due to Mr. A. Howard, C.I.E., Imperial Economic Botanist, who was good enough to bring the above facts to the former's notice and afforded all facilities to take samples from the Botanical area.

Scrapings of these were taken from two places in the drain where roots of *pipal* and tamarind respectively were known to have passed through. A sample of scrapings was also taken from the next drain further away from the river (Plate XXXV, fig. 1). The analyses are given below in Table III. To these are also added the analyses of scrapings taken from a mound round an existing bamboo clump (north-east of the Gonrhi field, Plate XXXV, fig. 2) and of some scrapings from a place where a bamboo clump had previously existed.

TABLE III.

Analyses of scrapings.

	From the drain (Pl. XXXV fig. 1)	From the drain where *pipal* roots had passed through	From the drain where tamarind roots had passed through	From bamboo clump (Pl. XXXV, fig. 2)	From a spot where a bamboo clump had previously existed
Calcium carbonate per cent.	0·11	0·06	0·06	0·23	0·11
,, sulphate	1·08	0·46	0·32	..	0·53
Magnesium sulphate	3·57	2·27	2·49	0·87	0·43
Sodium sulphate	14·34	4·51	13·11	7·43	4·60
Potassium sulphate	..	..	..	0·17	..
Sodium chloride	0·58	1·02	2·48	..	0·07
Potassium chloride	0·46	1·59	1·52	0·24	0·18
Potassium nitrate	traces	0·27	0·07	0·03	..
Total	20·14	10·18	20·05	8·97	5·92

All the scrapings were thus found to contain large amounts of soluble salts, the chief of these being sodium sulphate.

It has already been noted that some trees like *pipal* and bamboo are found to be very bad as to the formation of *usar* patches, while others such as *sissoo* are relatively speaking innocuous. The people explain that some trees are more "heating" (*garam*) than others. It seemed probable that roots of certain varieties of trees are richer in alkalies than those of others. It was therefore deemed desirable to find out whether there is much difference in the ash constituents of such roots. Roots of

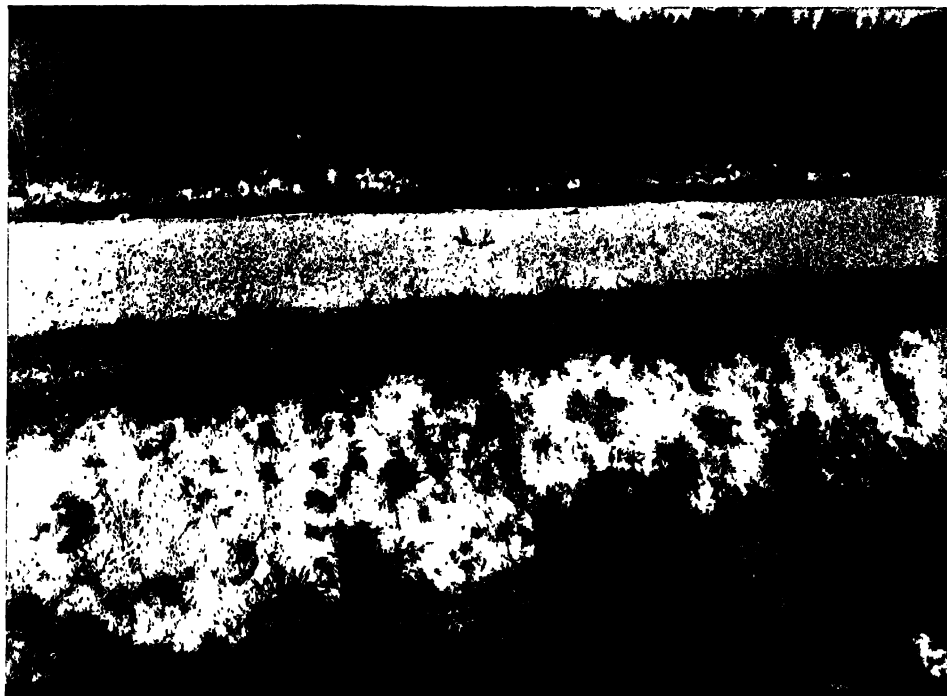


Fig. 1. REMOVAL OF *USAR* SALTS IN DRAIN-BOTANICAL AREA.













Fig. 2. INCRUSTATION IN A MOUND UNDER BAMBOO CLUMPS.

pipal, bamboo, and *sissoo*[1] were analysed with the following result :—

TABLE IV.

Composition of roots of different trees.

	Pipal	Bamboo	*Sissoo*
Per cent. ash calculated on dry stuff	12·54	8·78	17·00
	(Parts per 100 parts ash)		
Lime	30·38	9·18	45·70
Magnesia	4·31	1·93	4·61
Potash	12·87	7·57	4·54
Soda	traces	traces	0·33
Phosphoric acid	2·59	2·25	0·80
Hydrochloric acid	0·27	0·57	0·20
Sulphuric acid	0·48	1·88	0·34

It will be seen that although *sissoo* is more innocuous than the *pipal* and bamboo (so far as the formation of infertile areas of land is concerned) the root of the former is *richer* in ash constituents than the roots of the latter two. In fact the variation in the composition of the ashes does not show why *sissoo* is less harmful than the other two.

The writer had an occasion to discuss the subject with Mr. S. Milligan, the then Imperial Agriculturist (now Director of Agriculture, Bengal) who suggested that a possible explanation of these phenomena might be the movement of the soil solution towards a tree. A growing tree transpires an enormous amount of water. The roots have to abstract this water from the soil particles with which they come in contact. On account of the soil near about the roots thus getting drier than the rest of the mass of the soil, there sets up a movement of water from the wetter to the drier zone to restore the equilibrium. This movement continuously goes on with the growth of the tree. Along with the water, the dissolved salts present in the soil solution also move towards the tree.

An accumulation of *usar* salts is at times seen to occur in such parts of the fields as are more compact than the others. When there is a loss of moisture from the surface of a field, due to evaporation, there would be a freer flow of the soil water to these

[1] *Dalbergia Sissoo.*

parts on account of there being a closer capillary contact between the soil particles. This is often seen to be the case with roads. The traffic over a road "packs" the soil and the result is that owing to evaporation of moisture there is an accumulation of the soluble salts present in soil solution. This often leads to the formation of crusts in the roadside drains. The site of an old road in the Mysore field was infertile and covered with *usar* deposits (Plate XXXVI, fig. 1).

Pieces of brickbats lying in a field where saline deposits are liable to form are often found to serve as collectors of *usar* salts. Evaporation of the soil solution is much more rapid on the surface of the brickbats than on the soil of the field and the consequence is that the saline deposits first appear on the brickbats. This is also the reason why the surface of brick walls is at places covered with such incrustations. Where the level of the sub-soil water is not far distant from the surface of the soil, the water is brought up to the surfaces of bricks by the force of capillarity, and the comparatively rapid evaporation of the soil water at such places causes deposits of alkali salts. These salts often effect considerable damage, as they have a very harmful effect on the structure of the bricks.

A saline deposit was collected from the wall of one of the buildings at Pusa (Plate XXXVI, fig. 2) and was found on analysis to consist of the following substances :—

TABLE V.

Composition of scrapings from a brick wall.

Calcium sulphate	0·25
Potassium chloride	0·11
Potassium nitrate	20·86
Potassium sulphate	50·86
Sodium carbonate	0·20
Sodium bicarbonate	0·31
Sodium sulphate	17·46
Insoluble matter, moisture, etc.	9·95
	100·00

Like the scrapings collected from under trees these scrapings from walls were also rich in sulphates. There is an important difference, however. The latter were comparatively rich in potash



Fig. 1. SITE OF OLD ROAD, MYSORE FIELD.

Fig. 2. INCRUSTATON ON A WALL.

and in nitrates, which were only present in much smaller amounts in the scrapings collected from under the trees. This is likely to be due to the selective action of the roots of trees which absorb these constituents of the soil solution to a far greater extent than they do the others, but further study is required to prove this definitely.

To find out to what extent the infertility of the soil under trees was due to the accumulation of soluble salts, samples of such soils were collected from different places. In the majority of cases corresponding samples of fertile soil lying close by were simultaneously taken for comparison. The content of soluble salts and the amounts of moisture in the soils were determined. Measurements were also made of the rates of percolation of water through the soils. The results of the analyses are given in Tables VI and VII.

N. Pangarbi field. A boring was made in an infertile patch near a bamboo clump of the avenue on the border of the field (No. 1) and another sample taken a few yards away where the stand was quite good (No. 2). In Plate XXXVII, fig. 1, the point No. 1 is marked by a bamboo while a man is standing at No. 2. The general effect of the bamboo avenue is shown in Plate XXXIII.

S. Pangarbi field. A sample was taken at a point where there was formerly a bamboo clump (No. 3). This was covered with a white deposit and in Plate XXXVII, fig. 2, where the place is marked with a bamboo pole, the deposit round the bamboo was scraped off to show the underlying soil. Another boring was taken 10 feet away where the crop was doing quite well (No. 4).

Mysore field. In this field an existing road had been ploughed up. The crop did not grow on the parts through which the road had passed. A bamboo pole and a man mark the points (Nos. 5 and 6) where the samples were taken (Plate XXXVI, fig. 1).

Botanical area, near the river. Two samples were taken near the place from whence the first sample was taken and of which analyses of alternate 6 inches layers have been given (page 393). One (No. 7) was on an *usar* patch presumably affected by *pipal* and tamarind trees which stood a few yards away but were removed about two years ago. No. 8 was a few feet away where there was a good crop.

TABLE VI.

Moisture content of the soils and rates of percolation of water.

Depth of soil.	N. PANGARBI Bamboo existing		S. PANGARBI Bamboo previously		MYSORE Road previously		BOTANICAL AREA *Pipal* and Tamarind previously		BOTANICAL AREA Bamboo previously		Under *pipal*	Under bamboo
	Bad No. 1	Good No. 2	Bad No. 3	Good No. 4	Bad No. 5	Good No. 6	Bad No. 7	Good No. 8	Bad No. 9	Good No. 10	No. 11	No. 12
	Moisture per cent.											
0"—6"	2·49	3·54	16·15	8·16	19·62	10·17	19·87	8·08	5·90	8·08	24·19	16·38
6"—1'	3·32	4·58	17·14	10·29	20·78	10·03	27·31	7·79	8·18	3·16	21·65	15·12
1'—1' 6"	4·49	4·45	18·58	14·89	22·17	14·22	26·50	9·96	8·68	3·00	20·95	14·49
1' 6"—2'	4·67	4·96	19·07	12·25	19·32	17·73	25·56	13·40	10·23	5·22	23·95	14·63
2'—2' 6"	5·02	7·12	17·97	16·29	24·53	17·51	27·55	20·66	15·34	14·27	21·78	17·93
2' 6"—3'	6·71	9·33	19·79	16·75	27·33	23·13	28·90	26·87	24·09	21·24	23·04	15·04
3'—3' 6"	7·18	9·31	21·63	22·20	25·08	25·90	28·50	25·99	24·15	22·37	24·23	18·38
3' 6"—4'	7·66	10·06	14·67	18·60	22·28	22·37	27·51	20·12	26·16	25·60	21·71	23·09
4'—4' 6"	8·11	11·19	18·39	13·19	23·25	19·47	25·41	25·35	25·15	26·01	24·36	24·75
4' 6"—5'	8·72	13·62	21·45	17·93	27·79	21·32	23·89	27·81	24·78	21·32	26·44	24·70
5'—5' 6"	9·56	16·33	21·77	21·12	13·37	16·47	28·62	28·05	20·78	19·29	27·16	25·01
5' 6"—6'	11·87	20·47	23·78	23·56	12·79	10·32	29·86	28·41	25·12	24·57	28·66	24·22
	Percolation cm. per hour.											
First foot	0·4022	0·3795	0·0103	0·1386	0·1436	0·1917	0·0582	0·1073	0·1213	0·1980	0·1312	0·1980
Second ,, ...	0·5631	0·8106	0·0263	0·1188	0·0660	0·1155	0·0381	0·1485	0·0835	0·4868	0·0396	0·1073

	viously	BOTANICAL AREA Bamboo previously				Under *pipal*		Under bamboo	
	ood o. 8	Bad No. 9		Good No. 10		No. 11		No. 12	
	6″—1′	0″—6″	6″—1′	0″—6″	6″—1′	0″—6″	6″—1′	0″—6″	6″—1′
Total solids	·060	·100	·080	·090	·065	·160	·120	1·020	·380
Calcium (Ca)	·006	·002	nil	·006	·006	·011	·004	·027	·003
Magnesium (Mg)	·004	·002	·002	·003	·004	·010	·004	·015	·007
Potassium (K)	·010	·006	·006	·002	·003	·016	·016	·040	·002
Carbonic acid (CO_3)	·014	·030	·033	·023	·017	·028	·023	·026	·018
Hydrochloric acid (Cl)	·002	·002	·002	·001	·003	·005	·005	·042	·017
Sulphuric acid (SO_4)	·006	·006	·003	·002	·004	·014	·012	·545	·197



Fig. 1. EFFECT OF BAMBOO, N. PANGARBI FIELD.
(This shows a part of the field illustrated in Plate XXXIII.)

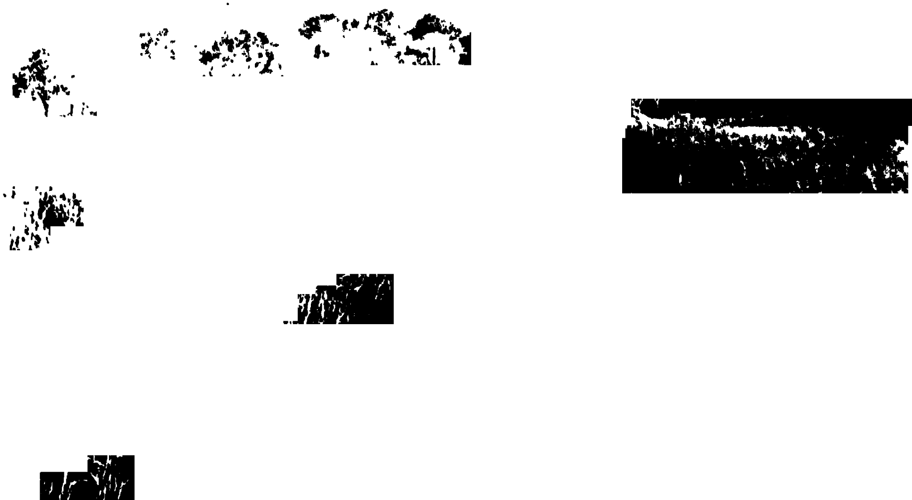


Fig. 2. EFFECT OF OLD BAMBOO CLUMPS, S. PANGARBI FIELD.

Near the fencing at the south-east corner. At No. 9 a bamboo clump had stood previously. No. 10 is a few feet away where the crop was flourishing quite well.

Beneath pipal trees, in Gonrhi field. A boring (No. 11) was taken. There was coarse grass growing at the place.

Under a bamboo clump. Just outside the Botanical area a boring (No. 12) was also taken.

An examination of the moisture contents of the soil showed that infertility is not generally due to a deficiency of moisture. In the samples from S. Pangarbi, Mysore, and the two places in the Botanical area, it was seen that the "bad" soil contained more moisture than the "good" soil. The lower percolation rates would account for a "bad" soil losing water less rapidly. In the samples from N. Pangarbi the "bad" soil contained less moisture at all depths as compared with the "good" soil, but the difference was not much in the top layers. Whether this is due to the abstraction of water by the bamboo cannot, however, be definitely stated. It is proposed to carry on further studies on this subject.

In another place (No. 12) the soil under bamboo was more moist than the soils referred to above, but it was at the same time more retentive, as shown by the lower percolation figures. In fact in cases like these it is necessary to make comparative studies of fertile and infertile patches on the same field rather than merely to compare figures relating to soils from different places. It is well known that the amount of water held by a soil and the rate of its movement are primarily influenced by the nature of the soil.

The rates of percolation are generally higher in the "good" soils than in the "bad" ones. Both the "good" and the "bad" samples from N. Pangarbi were, however, equally permeable to water.

The "bad" soils were generally richer in soluble salts than "good" soils from the same plot. The samples from the Botanical area (Nos. 9 and 10) were, however, exceptional. In the samples from N. Pangarbi the "good" and the "bad" soils were practically similar as to the content of soluble salts, which were present, moreover, only in very small quantities. It is apparent that in this

instance the infertility was not due to any accumulation of soluble salts. The rates of percolation were also about the same in the above cases and approximated to those of ordinary good arable soils.

It was thought then an examination of these figures would help in the determination of the toxicity of soluble salts present in soil, *i.e.*, in finding out the amount of salts which prohibits the growth of crops. It may, from the above analyses, be tentatively maintained that under the conditions obtaining at Pusa "good" soils contain not more than 0·3 grm. of soluble salts (generally very much less) and that "bad" soils often contain 0·5 grm. per 100 grm. soil. But these assertions do not hold universally. Much seems to depend on the nature of the salts.

In sample No. 6 ("good" soil) where the concentration is about 0·3 grm. it was at first thought that much of the dissolved salts might be nitrates. It was found, however, that the amount of nitric acid was very small—0·01 per cent. which was about the same as that contained in the corresponding "bad" soil (No. 5) and in the soil collected from under the *pipal* tree (No. 11). On the other hand the "good" soil (No. 4) contained 0·04 per cent. nitric acid.

The fact that a "good" soil (No. 6) should contain a fairly high amount of dissolved salt but be still innocuous might at first sight seem peculiar. An examination of the analytical data, however, showed that the major part of the salts consisted of the relatively harmless calcium sulphate. Not only did the corresponding "bad" soil (No. 5) contain more dissolved salts but these also were of a more toxic nature, being mainly sodium sulphate and chloride.

Some further observations, as to the influence of the growth of bamboos on the moisture and soluble salts present in the soil, have been made (*see* Tables VIII and IX). The bamboo clump from under which was collected soil No. 12 (*see* p. 399 and Tables VI and VII) was cut down before the rains set in and the place levelled. Soils from this place as well as from under an existing bamboo clump (about 18 yards away from the former) were periodically examined, from October onwards, with the following results:—

TABLE VIII.

Effect of growth of bamboos on soil moisture.

Percentage of moisture in the soil.

Depth of soil	31st October, 1916		14th November 1916		14th and 15th December 1916		12th January, 1917		14th February, 1917	
	Bamboo existing	Bamboo removed	Bamboo existing	Bamboo removed	Bamboo existing	Bamboo removed	Bamboo existing	Bamboo removed	Bamboo existing	Bamboo removed
0"—6"	22·28	23·89	17·98	22·50	8·98	16·01	4·49	11·11	13·78	20·48
6"—1'	24·89	29·23	20·84	20·31	11·32	19·20	3·88	14·53	15·64	16·30
1'—1' 6" .. .	28·01	28·22	25·86	23·81	17·18	20·64	5·85	19·15	15·33	15·95
1' 6"—2'	24·82	27·06	25·16	23·01	19·01	19·65	6·56	12·78	15·30	15·50
2'—2' 6"	28·44	30·39	24·35	26·36	19·85	20·99	13·07	19·26	16·96	16·29
2' 6"—3' . .	29·38	32·20	26·17	28·41	22·32	24·49	17·42	23·48	18·67	20·35
3'—3' 6" .. .	29·22	26·53	26·44	29·34	19·55	24·58	15·04	21·53	19·59	18·59
3' 6"—4'	29·28	28·95	27·07	28·89	22·32	28·44	19·00	24·04	20·32	23·20
4'—4' 6"	28·97	29·15	27·88	29·80	26·27	25·38	21·64	26·59	26·03	26·65
4' 6"—5' . .	26·00	26·16	26·83	25·42	25·27	26·44	24·28	25·47	26·29	26·36
5'—5' 6" . ..	26·42	29·71	25·38	25·00	24·45	25·08	24·69	25·21	24·96	24·82
5' 6"—6'	27·18	27·81	25·20	27·04	25·73	24·12	24·64	24·65	24·44	25·94
6'—6' 6"	28·28				22·04	24·13	23·34	27·11	23·31	27·02
6' 6"—7' . .	27·01				24·77	24·83		25·25	23·34	26·14
7'—7' 6" .	28·82				27·39	24·24		25·52	27·73	26·72
7' 6"—8' .. .	27·84				28·32	29·45		26·03	25·25	28·08
8'—8' 6"	31·23				25·45	28·74		28·45	28·34	28·78
8' 6"—9' .. .	30·59				26·28	28·49		27·36	26·36	26·67

The above shows the extent to which bamboos rob the soil near about them of its moisture. The first foot of soil suffers the most.

The amounts of the soluble salts in the soil are given in Table IX.

In general a greater amount of soluble salts is present in the upper layers of the soil near the bamboos as compared with similar layers away from the clump. In the lower depths, however, the soil away from the bamboos contains more soluble salts than that near the clump. The figures seem to support the view about a movement of soluble salts towards the bamboos.

An interesting confirmation of a similar increase in the concentration of soluble salts in the soils nearer a big tree was met with in the case of a tamarind tree. Samples of soil, 6 inches deep, were collected in a straight line at different distances from the tree. The line of samples was so chosen that these latter were least subjected to the disturbing effects of other existing trees. The soils contained the following amounts of soluble salts :—

	Per cent.
Soil just near the tree	0·276
Soil 10 ft. away from "	0·414
Soil 20 " " " "	0·118
Soil 30 " " " "	0·100
Soil 40 " " " "	0·084
Soil 50 " " " "	0·082

With the exception of the first sample, the soils show a regular fall in the content of soluble salts as the distance from the tree increases.

Turning next to some of the factors in such accumulations of soluble salts it is to be noted that in a subject like this there are many points to be taken into consideration. In the first place much of the salts may be in the solid form as a crust on the surface and thus practically exerting no influence on the activities of the roots underneath. It is only the dissolved matter in the soil solution which counts. It is for this reason that in the course of the present work both the 0″—6″ and the 6″—1′ layers have been analysed.

TABLE IX.

Effect of growth of bamboos on the content of soluble salts in soil.

Percentages of soluble salts in the soils.

Depth of soil	31st October 1916		14th November 1916		14th and 15th December 1916		12th January 1917		14th February, 1917	
	Bamboo existing	Bamboo removed	Bamboo existing	Bamboo removed	Bamboo existing	Bamboo removed	Bamboo existing	Bamboo removed	Bamboo existing	Bamboo removed
0″—6″	1 045	0 703	0 834	0 198	0 202	0 396	0 146	0 496	1 268	0 460
6″—1′	0 505	0 035	0 630	0 192	0 144	0 204	0 094	0 246	0 392	0 192
1′—1′ 6″	0 483	0 045	0 550	0 160	0 190	0 196	0 058	0 204		
1′ 6″—2′	0 338	0 038	0 475	0 170	0 114	0 166	0 060	0 240		
2′—2′ 6″	0 370	0 050	0 390	0 244	0 100	0 170	0 024	0 218		
2′ 6′—3′	0 300	0 070	0 318	0 318	0 090	0 276	0 042	0 284		
3′—3′ 6″	0 210	0 120	0 216	0 306	0 088	0 296	0 058	0 292		
3′ 6″—4′	0 230	0 164	0 170	0 514	0 114	0 350	0 050	0 346		
4′—4′ 6″	0 324	0 290	0 138	0 616	0 118	0 400	0 056	0 384		
4′ 6″—5′	0 354	0 450	0 130	0 520	0 154	0 482	0 106	0 344		
5′—5′ 6″	0 204	0 430	0 290	0 580	0 166	0 398	0 060	0 440		
5′ 6″—6′	0 205	0 390	0 296	0 450	0 152	0 406	0 070	0 456		
6—6′ 6″	0 215				0 106	0 398	0 098	0 412		
6′ 6″—7	0 254				0 158	0 376		0 416		
7′—7′ 6″	0 228				0 108	0 338		0 386		
7′ 6″—8	0 222				0 144	0 372		0 306		
8′—8′ 6″	0 226				0 176	0 308		0 336		
8′ 6″—9′	0 200				0 150	0 322		0 340		

The moisture content of the soil is also a controlling factor, as, given the same amount of salts, this determines the concentration.

The texture of the soil must also be taken into consideration. Loamy soils can contain a relatively larger amount of salts without producing injury than is the case with sandy soils. From the point of view of the practical farmer the texture of the soil is of high importance inasmuch as an open soil can more easily get rid of saline matters by irrigation and drainage. It is to be remembered, however, that soluble salts produce an injurious effect on the texture and a local accumulation of these, whether due to plant growth or water-logging, gradually aggravates the trouble by hindering the free movement of the soil water.

Then again different crops can tolerate varying amounts of alkali salts, some being distinctly alkalophile, while others may be looked upon as alkalophobe.

Lastly, as already pointed out, the nature of the salts is of great importance. Some salts are more toxic than others and a mixture of salts may have either additive or antagonistic effects which can only be found out by actual experiments.

The problem of the formation of infertile patches by the growth of trees is thus seen, like many other questions of agricultural interest, to be somewhat complicated. In many instances, though not in all, this is associated with the presence of injurious amounts of soluble salts. It is interesting to note that Ramann and Niklas[1], after observing for two years the concentration of the solutions of an upland peat moor soil supporting a stand of birch, pine, and other trees, found that the soluble salt content of the forested soil was generally larger than that of the bare soil.

The accumulation of soluble salts might be due partly to the leaching out of the mineral matter in the dead remains of the plant (decayed roots and fallen leaves) but transpiration by the plant is likely to be an important factor. On this assumption, plants having a high transpiration ratio would produce harmful results quickly. It may be that plants having thin or small leaves (tamarind, *pipal*, etc.),

[1] *Experiment Station Record*, vol. XXXV, p. 512 (1916).

transpire relatively more water than trees having thick leaves (*bar*).[1] The extent and the distribution of the root-system are also of importance. Plants having a smaller root-range relatively to the transpiration would, of course, effect a greater local concentration of salts. Again, the injurious effect may be apparent soon if the roots are mostly in the top layers of soil. These considerations might probably hold in the case of bamboos.

It must, however, be remembered that other factors also most probably have influence. Competition for sunlight and for plant food (including water and oxygen), inability to rapidly get rid of some of the injurious products of the vital activities of the plant (including carbonic acid) are some of these.

Turning now to the remedies which can be tried in such cases of infertility, the removal of the tree is the first step to be taken. After this, attempts should be made to effect a permanent improvement in the texture of the soil by means of deep cultivation and the addition of organic manures. Proper drainage facilities should be provided so that the salts may readily pass out of the soil. In some cases it may be necessary to have recourse to an efficient system of irrigation (combined with suitable provision of drainage) to get rid of the accumulated *usar* salts.

It is proposed to carry out further studies on this subject.

[1] *Ficus bengalensis*

CO-OPERATION: A REVIEW.*

BY

J. MACKENNA, C.I.E., M.A., I.C.S.,

Agricultural Adviser to the Government of India.

Many books have been written on co-operation, but the majority of them are the work of abstract economists who have given us an historical account of what has been accomplished in the different countries where it has been tried or a study of the economic principles underlying it. Few treatises of any size have been written by practical co-operators. But with all respect to our political economists and with a due appreciation of the help which their work has been to the cause, we venture to say that the most valuable and most practical suggestions are likely to come from those who have had practical experience of all the details of the movement. It is one thing to write of the subject as an abstract economic movement: it is another to write with the fullness of inside knowledge, the insight of one who has seen its growth from the isolated village societies—one dotted here and another there—to the larger federation of societies linked into unions and drawing their resources from a Central or Provincial Co-operative Bank. There can be no greater feeling of personal satisfaction than to recall the memory of early individual struggles with isolated groups of villages, distrustful and slow of conviction, and to see them now swallowed up in the victory of a great unified and centralized scheme. The halting, timid children have grown to manhood and can look after themselves with the confidence which a vigorous manhood inspires.

* Co-operation: Comparative Studies and the Central Provinces System, by H. R. Crosthwaite: Thacker, Spink & Co., Calcutta, price Rs. 6.

The early difficulties are forgotten : the shy and suspicious villager has come to " know himself " and to take a pride in himself and is an active and intelligent member of a progressive economic movement. " Good economy is apt to produce good morals, and if the movement is to destroy the forces of ignorance and waste, co-operators must be conscious of the efforts and sacrifices which their cause requires."

The credit of producing a work on co-operation worthy of the extent to which the movement has developed in India falls to Mr. H. R. Crosthwaite, Registrar of Co-operative Societies in the Central Provinces, and, with the probable exception of Mr. English of Burma, the officer who has been for the longest term identified with co-operation in this country. While the work is limited to the author's experience in the Central Provinces and Berar, it is sufficiently wide in outlook to make it of very general interest and applicability, and it may well be taken as a guide and model for all provinces of India.

We may at once remark that the style of this book is so fascinating that it is difficult to call a halt for purposes of criticism In the first few pages of his book which the author calls " some pages of commercial history " we have a fine picture of the history of British influence in India : the commercial period —a period of war and territorial expansion : and finally a period of consolidation and internal progress. With equal brevity and clearness the genesis of the Central Provinces and Berar is described, while another chapter graphically depicts the remarkable progress of the last hundred years. The first part of the book is a model of precision and graphic description and its lessons are summed up by the writer as follows (we cannot improve the style and make no apology for the length of the extract) :—

" So far I have tried to suggest to the student of economic history a train of thought which he can pursue and work out for himself. Briefly, Western influences are moulding the destiny of the East ; world progress, far more rapid than it was, will, with every improvement in communications, become still more rapid ; and India cannot, any more than any other country, hope to be able to stand aloof from the struggle for existence. Organization,

co-operation, the desire to work for the future rather than to dwell complacently on the achievements of the past—these are the characteristics of modern national life. Now the mere fact that a country possesses an educated class will not necessarily ensure a prosperous future for it. If the educated and enlightened are disproportionate in numbers to the mass of the population, and if, speaking generally, the people of a country are, as a body, ignorant of what is going on in the world outside their own country, there will be no widespread appreciation of the necessity for effort. People will live on in the comfortable assurance that their business, their farming, their living, are proceeding on lines which, however old-fashioned, are quiet and peaceful and, on the whole, quite satisfactory to themselves ; and this state of self-complacency will continue until the more energetic people of other countries capture for themselves by *co-operative organization* the trade and the markets of the dreamers and the slumberers. Higher education is, of course, a necessity ; but every man cannot be highly educated at any rate for thousands of years to come. Higher education, technical or of some other kind, will provide leaders of men and captains of industry. But something much more effective in immediate application, much quicker in widespread result, is necessary if there are to be men to be led and to be organized. General education of a kind that schools and colleges cannot possibly give is the vital need of modern India. Exactly the same statement has been made in the past by Russian statesmen about Russia, by Japanese about Japan, by Irishmen about Ireland, by Italians about Italy ; turn where you will, there is scarcely a country which has failed to create for itself a school for the moulding of popular character, for the stimulating of individual enterprise, and for the dispelling of general ignorance. It has been and is the object of these truly national schools to inculcate amongst the people, as a national asset, the virtues of self-help, thrift, honesty, punctuality, self-restraint, an ability to take the initiative, the will to work together—in short, *the spirit of co-operation.* Such a school exists where there is a genuine co-operative movement in receipt of the necessary measure of supervision from the State and of support from the people.

"We may now proceed, in a series of short and not absolutely comprehensive studies, to examine some of the results obtained, remembering always that the State alone has never been able to make a co-operative movement. It is true that in almost every country—England and Germany are notable exceptions—the first impetus has been given either by Government or by officers of Government : it is also true that every Government, however antagonistic at first, has eventually given its active support to the movement. But co-operation has never yet in any country become a powerful and regenerating force unless (*i*) attention has been devoted to the moral as well as the material necessities of the people, (*ii*) leaders of education and enlightenment have been found *from the ranks of the people* to preach and to work, (*iii*) effort has been co-ordinated, guided, and disciplined by paid professional experts, (*iv*) sympathetic encouragement and assistance have been forthcoming from Government, and (*v*) the members of co-operative societies have been made to think, act, and carry out the essential details of the work of their societies *for themselves*. Spoon-feeding by Government is, in its way, far less harmful (because far easier to stop), than spoon-feeding by parent co-operative institutions of the societies for which they are responsible. An excellent motto for every practical co-operator is this : 'Never do for another co-operator what he ought to do and can be taught to do for himself'."

This is the whole position in a nut-shell : it could not be more tersely expressed.

In Part II of his work, Mr. Crosthwaite gives a masterly review of the development of the co-operative movement in various countries. He describes the systems of rural credit in Great Britain and Ireland and in Germany. He then passes to a consideration of central organizations—such as Unions, Federations, and Central Banks. A considerable amount of space is devoted to the Prussian Central Co-operative Bank for the details relating to which the author expresses his obligation to Mr. Cahill's exhaustive review. Mr. Crosthwaite sums up the position as follows :—

"Our survey of the German system of rural co-operative credit has not thus far revealed any excessive amount of interference by,

or of aid from, the State. Money-lenders, however, generally dictate their own terms to their clients; and if the State is to be the money-lender of the co-operative movement, then there must be, inevitably, a far greater degree of State supervision and control than is good for the fostering of those qualities which are summed up in the term 'the co-operative spirit.' There is, accordingly, a general consensus of opinion amongst co-operators in countries outside Germany that the Prussian Central Co-operative Bank has not been an unqualified success; and although the other parts of the German co-operative system have been widely accepted as admirable models, it is a significant fact that the Prussian Central Co-operative Bank has not been directly imitated."

A particularly interesting section is that in which the author describes the co-operative movement in Japan. He points out that in Japan the social and moral good arising from co-operation is placed above the economic benefit. Thrift is the root idea of the whole system: good conduct is an essential condition of membership; charity and the succour of the needy are amongst the principal duties of societies. The system is strongly interwoven and bound up with the imperial and national aspirations of Japan. Mr. Crosthwaite describes the various systems of Japan in a most delightful manner and the chapter must be read as a whole to be adequately appreciated: quotation would only mar the general effect. The picture is one of co-operation acting as a great moral and material force for the improvement of the individual and the moral and material advancement of the nation.

From this stage onwards the book becomes more technical though the charm of style preserves this technicality from any trace of dullness. Those of us who have had experience of co-operation in a predominatingly agricultural country such as the Central Provinces will probably agree with the author that industries must follow agriculture. "Any attempt to prop up decaying industries, that is to say, industries the products of which are being pushed out of the market by better, cheaper, and more popular articles by means of co-operative credit, is doomed to failure." Such industries are

those of cotton weaving, bleaching, dye making, bangle making, and oil pressing. On the basis of experience Mr. Crosthwaite does not recommend " Class industrial societies " but considers " Peoples' Banks " the best means of preserving industries. " Co-operation in agriculture will lead to industrial co-operation. A great deal can be done for selected individual artizans and traders and other classes as well by means of suitable organizations for the provision of reasonable credit and above all the promotion of thrift."

Next we are introduced in succession to the details of working of the Schulze-Delitzsch Banks of Germany and the Luzzati Banks of Italy, and to all the mysteries of long term credit, co-operative mortgage credit, and the " Ginko " of Japan.

Two interesting chapters follow on Co-operation in Agriculture and the Co-operative Store. The former deals with agricultural societies for supply or purchase of commodities necessary for agriculture, and with the sale and production of agricultural produce. Descriptions are given of an Irish Co-operative Dairy, of the Lucknow Co-operative Dairy Society, of a German Granary Society, and of Swiss Cattle Breeding Societies. The principles underlying cattle insurance are next explained.

Of the co-operative store, Mr. Crosthwaite says :—" For town dwellers in India, the co-operative store as an immediate means of economy, thrift, and general education ought to possess great attractions. As an ultimate agency for the promotion of home industries the store deserves serious consideration."

Parts III and IV are devoted to the co-operative system in the Central Provinces and Berar and are practically a working handbook of instructions for co-operators. These sections will probably prove of more interest to the practical co-operator than to the general reader, but they supply a valuable insight into the detailed working of the co-operative system and as such may prove valuable to Registrars and others working on the development of co-operation in other provinces.

We congratulate Mr. Crosthwaite on the thoroughness and completeness of his work which he modestly describes as a " book

prepared by a humble co-operative worker for the use of his fellow-workers." Such it undoubtedly is, and co-operators not only in the Central Provinces and Berar but throughout the other provinces of India will acknowledge with gratitude their obligation to Mr. Crosthwaite for the complete and exhaustive treatise on Indian Co-operation which he has produced. The book will rank not merely as the first comprehensive survey of co-operation in India but also as a valuable contribution to the literature of Indian economics.

THE PLANTING INDUSTRIES OF SOUTHERN INDIA.

BY

RUDOLPH D. ANSTEAD, M.A.,

Deputy Director of Agriculture, Planting Districts.

THE planting industries of Southern India comprise a number of different products—Coffee, Ceara and *Hevea* Rubber, Tea, Pepper, Cardamoms, Cinchona, Sisal Fibre, Fruit, and a little more or less experimental Camphor.

The three main crops are coffee, tea, and *Hevea* rubber, and the object of this paper is not to deal with these in a statistical way, nor to describe the methods of cultivation adopted, but rather to try to sketch the early history of these industries and the romance which attended their early days.

The oldest planting industry in Southern India is coffee and this product has had a most romantic career. Its earliest history is shrouded in mystery and veiled in legends. The plant is indigenous to Ethiopia and it was probably introduced from that country into Abyssinia about 875 A.D. by marauding tribes. These tribes are said to have used as food balls of grease mixed with a brown powder, which enabled them to support life and withstand hardships and privations on their forays. This brown powder proved to be coffee. From Abyssinia it reached Arabia, Syria, Persia, Turkey, and other countries in Asia.

An Arabian legend has it that a goat-herd noticed that whenever his flock happened to browse on the leaves and fruit of a certain plant, they became excited. A mullah being informed of this resolved to try the effect of the fruit on his monks, whom he had

* A paper read at the Fourth Indian Science Congress, Bangalore, 1917.

considerable difficulty in keeping awake during their nocturnal devotions. The experiment became a success and the sleep-repelling bean turned out to be coffee.

There are a number of similar legends, but the true history of the discovery of the value of an infusion of the coffee bean as a beverage is unknown.

No food product has ever had to face as much opposition as coffee. Religious superstition had to be overcome, Mahomet condemned it and forbade it to the Faithful; political opposition was encountered, in 1675 Charles II attempted to suppress coffee houses under the pretext that they served as meeting places for the disaffected, who invented and circulated false reports calculated to defame the Government. It has been attacked by the medical profession as a drug; it has suffered from fiscal restrictions, exorbitant taxes and duties; but it has triumphed over all these obstacles and to-day has become a world-wide popular beverage.

Tradition has it that coffee was introduced into Southern India by a Mussalman pilgrim named Baba Budan, who brought seven seeds with him in 1600, which he planted round his hut on the slopes of the hills above Chikmagalur in the Mysore State. Some of the original trees which grew from this seed will be shown you to-day in this locality, and should you be sceptical, there are the Baba Budan Hills to convince you of the truth of the story.

In any case coffee was undoubtedly introduced from Aden to the Malabar Coast about the year 1700, and a description of it is to be found in a Dutch work entitled *Letters from Malabar*, written by Jacob Visscher, one time Chaplain at Cochin, about 1743. In *Heynes Tracts*, published in 1800, it is recorded that coffee was being sold in the bazaars of Bangalore and Seringapatam. In 1880, 500,000 acres of land are said to have been taken up for coffee cultivation. Much of this has died out, either from mistaken methods of cultivation, old age, or disease, and in some cases it has been replaced by tea, but it is still the most extensively cultivated crop in planting districts of Southern India, and there are to-day some 200,000 acres scattered all along the hills from the northern limits

of Mysore, through Coorg, the Nilgiris, Shevaroys, and Pulneys, to Cochin and Travancore.

The next biggest planting industry is tea. The tea plant is indigenous in Assam where it occurs in the wild state as a small tree reaching a height of 30 to 90 feet. It has probably been distributed from this general region to those parts of the East where it is cultivated. There is apparently only one species, the *Thea sinensis* of Linnæus, and the many varieties known and cultivated have been developed from this.

Tea is also indigenous in China, and in that country its use and cultivation first originated, though the history of its discovery is again merely a mass of legends.

At an early period the British East India Company, as the principal traders between China and Europe, became interested in the question of the possibility of tea cultivation in India, which was first definitely recommended in 1834 by the Governor-General, and a Commission was appointed to consider the matter. This Commission recommended the Himalayas, Assam, and the hills of Southern India as suitable districts for the venture, but unfortunately overlooked the merits of the indigenous Assam plant and advised the trial of plants imported from China. This resulted in failure. The China variety of tea has now been entirely replaced by the indigenous variety and hybrids thereof, and it is seldom to be seen nowadays on estates. In 1840 the Assam Tea Company was formed and this date may be said to be the starting point of the Indian tea industry which has now reached large proportions. To-day there are some 640,000 acres of tea in India of which 64,000 acres are under cultivation in the south, chiefly in the hill tracts of the Nilgiris, Wynaad, Malabar, Cochin, and Travancore.

The latest planting industry of any considerable size to be established is *Hevea* rubber, and the story of the introduction of this crop to the East is one full of romantic enterprise. Sir Clements Markham, who introduced cinchona with success, took up the question of the introduction of rubber in 1870. In 1872 a report was made on the subject by James Collins, and the next year he brought a few seeds from the Amazon; but the first large supply of

seed was brought home to Kew by H. A. Wickham in 1876. Wickham was commissioned to supply *Hevea* seeds to the Indian Government, but the Brazilian authorities opposed their export. Wickham, however, was a prince of smugglers; he chartered an ocean-going steamer trading to the Amazon which had been abandoned without a return freight, and on to this steamer he loaded 70,000 rubber seeds, got them passed by the port authorities as botanical specimens, and brought them safely to Kew, where subsequently some 4 per cent. of them germinated. In 1876 two thousands of the resulting seedlings were sent to Ceylon in Wardian cases and put down in a special garden which had been prepared in readiness for them at Heneratgoda.

In 1879 twenty-eight plants from Ceylon were planted in Southern India at Nilambur, a site first suggested by Colonel Beddome, the Conservator of Forests in 1877. In 1886 three more were received from Mr. F. J. Ferguson who was experimenting with rubber at Calicut. A year or so later a number of plants were put down at the foot of the Calicut ghaut, and sixty of these trees exist to-day. They have stood fire and neglect and have been gashed by all sorts of experimental tapping, but are still noble trees.

The original plantings were all neglected and most of the trees in them allowed to die and the experiment was considered a failure until in 1903 Proudlock, Curator of the Government Parks and Gardens at Ooty, reported favourably on the West Coast country as suitable for rubber planting.

The first rubber estate in Southern India was opened in 1902 at Thattakaad on the banks of the Periyar river in Travancore. This was followed in 1904 by estates in Mundakayam and South Travancore, and in 1905 by estates in Cochin; since then many estates have been opened in these districts, as well as at the foot of the Nilgiri and Wynaad Hills, in Malabar, Mysore and elsewhere, and to-day there are some 60,000 acres under rubber cultivation in Southern India.

It is of interest to compare the position of rubber to-day and its manifold uses in the arts of peace and war with its position a

century or so ago. It was first introduced as a commercial article in 1770 when Priestley recommended its use for erasing pencil marks. For many years this was almost its only use, though bottles were made out of it to some extent. In 1820 Hancock established the first rubber factory in England. It was not till 1823, less than a hundred years ago, when Mackintosh discovered how to dissolve it in coal tar naphtha and use it for waterproofing garments, that the possibilities of this material began to be realized, and rubber as we know it now was not possible till Goodyear discovered the process of vulcanisation in 1839.

The planting industries of Southern India are now so firmly established over large areas that one is apt to forget that it is only comparatively recently that they were introduced. There are still to be met planters who came to this country in sailing ships *viâ* the Cape, and took weeks and months to reach the estates by bullock carts. But what of the pioneers who forced their way through almost impenetrable jungle to totally unknown and unexplored districts? What of the difficulties they overcame, the organization of labour, the felling of the forest, the raising and planting out of the new crops? They lived in rough mud and timber huts, without any of the modern luxuries of soda water and tinned food, and built up the great planting industries as we see them to-day. The difficulties of getting the produce to the market when it had been grown were enormous in the days when railways were non-existent and roads and bridges few. It was sent down the ghauts by pack ponies and on coolies' heads and then for weary slow miles by bullock carts along bad roads. Men still tell of the days when they bargained with the hill tribes of robbers to escort their coffee to the coast for a consideration and guarantee that a certain reasonable proportion of it should reach its destination.

These things were done only yesterday in districts where now the motor car is a common means of travel.

Even the recently introduced rubber was established in the face of great difficulties. Much of it is planted in the foot hills along the West Coast in dense jungle, and at the time the clearings were made roads and bridges were few and far between. Places to

which one can now drive in a car and find luxurious bungalows lighted with electric light, and factories run by electric power, wire rope-ways, motor lorries, and all the signs of modern development, could only a very few years ago be reached by the bullock cart and often only on horseback or on foot. In the monsoon large districts were cut off from the outside by flooded and unbridged rivers, and fever and illness were things to be dreaded. In more than one district it was for a time a battle between nature allied with fever and weeds and the will of man to overcome.

Every year the planting districts are developing, the means of transport are improving, the mechanical facilities are extending, and in the rush of development the romance of the early days, the memory of the pioneers and their difficulties, their British pluck and determination are apt to be crowded out and forgotten.

WATER HYACINTH (*EICHORNIA CRASSIPES*) AND ITS VALUE AS A FERTILIZER.*

BY

R. S. FINLOW, B.Sc., F.I.C.,

Fibre Expert to the Government of Bengal,

AND

K. McLEAN, B.Sc.,

Deputy Director of Agriculture, Eastern Bengal.

In recent years the growth of water hyacinth (*Eichornia crassipes*)—vernacular: *Kachuri, Tagoi, Belati pana* in Bengal—has increased to an alarming extent in the Dacca District of Bengal, and it now threatens to interfere seriously with, if not entirely prevent, navigation in many of the minor watercourses of the district. The matter was brought to the attention of the Governor of Bengal, Lord Carmichael, by the Narayanganj Chamber of Commerce about two years ago, and, at the instance of His Excellency, an investigation was commenced, the object being to find a means of eradicating the hyacinth or of mitigating the danger to what are, during a considerable portion of the year, the only means of communication over considerable tracts in Eastern Bengal.

In the course of the investigation it was discovered that (*Eichornia* sp.) is a serious pest, interfering with navigation in Burma, Indo-China, Australia, and in Florida. In Madras it has been the subject of a note written by the Director of Agriculture ; in Burma it has been described as one of the greatest administrative problems

* A paper read at the Fourth Indian Science Congress, Bangalore, 1917.

at present confronting Government, and special legislation has been carried through with the object of eradicating it. In Indo-China elaborate investigations have been carried out with the object of finding an economic use for the very large quantities of organic matter which are to be disposed of; but, as in the case of "Sudd," a water weed which has caused such difficulties in the navigation of the upper reaches of the Nile, the investigations have apparently tended chiefly towards commercial exploitation of the weed, such as the manufacture of paper and the extraction of salts of ammonium. In Cambodia, Professor Perrot proposes to use the fibrous matter of the plant for the manufacture of bags to replace jute gunnies now imported from India.

So far as our information goes, no commercially successful enterprise has as yet been based on water hyacinth and it was decided, in the first instance, to investigate its agricultural possibilities. Results of considerable importance have been obtained and a detailed report on the investigation is being issued; but it is thought that a short note, embodying the conclusions so far arrived at, may be of interest to members of this Congress.

Mr. H. G. Carter, Economic Botanist to the Botanical Survey of India, has kindly furnished us with the following technical description of water hyacinth :—

"*Eichornia crassipes*, Solms, belonging to the Family PONTEDERIACEŒ, is a native of South America, but has now become a troublesome weed in other countries, notably Florida, Java, Australia, and India. The plant is a herb, which multiplies extensively by division of the root-stalk.

"When floating in water the plant has large bladder-like leaf-stalks which make it remarkably buoyant. The blade of the leaf acts as a sail, so that the plant, which multiplies very rapidly, is carried about on the surface of the water and soon becomes a pest. ʰen growing in mud the bladder-like expansion of the leaf-stalk ent. The plants bear spikes of ten or twelve handsome lilac The perianth is funnel-shaped and usually slightly irre- ends in six lobes. The six stamens are inserted on the The ovary is superior and three-celled and has axile

placentation. The fruit is a loculicidal capsule containing seeds with abundant mealy endosperm."

The apparent resemblance of the flower of *Eichornia crassipes* to that of the true hyacinth (*Hyacinthus orientalis*, Liliaceae) is responsible for its English title ; but it is hardly necessary to say that no botanical relation exists between the two plants.

Examination of the water hyacinth in the laboratory showed, as was expected, that the fresh plant contains a very large proportion of water (95 per cent.) as the following approximate figures show :—

		Per cent.
	Moisture	95·50
	Organic matter ..	3·50
	(containing Nitrogen)	0·04
	Ash	1·00
Containing	Potash ..	0·20
	Phosphoric Acid	0·06

The residue proved to be rich in potash ; indeed the potash content of hyacinth, though somewhat less than that of the sea-weeds belonging to the genus *Laminaria*, the best marine source of kelp, is, apparently, distinctly richer in this respect than *Fucus*, which is also used for making kelp. Of course the kelp also contains iodine, which is a valuable constituent ; but the respective problems involved in the use of seaweed and of water hyacinth, either as an organic manure or for the production of ash, are not dissimilar.

The high potash content of water hyacinth is of considerable importance in North-Eastern India where the soils, which are not subject to renewal by silt from the monsoon floods, are, on account of the leaching effect of the heavy rainfall, generally deficient in lime, potash, and phosphoric acid. This is especially the case in the two extensive laterite areas, *viz.*, the Madhupur jungle in Eastern Bengal (Dacca, Mymensingh, and Tipperah districts), the Bahrind (Rajshahi, Bogra, and Dinajpur) in Western Bengal and, probably also, other large areas in Assam.

The analytical figures indicate that the rotted water hyacinth is about as rich as farmyard manure, of the same water content, in nitrogen, phosphoric acid, and lime ; but it contains several times as much potash.

The ash is about 1 per cent. of the fresh green weight and its approximate content of important constituents is as follows:—

	Per cent.
Potash (K_2O)	28·7
Soda (Na_2O)	1·8
Lime (CaO)..	12·8
Phosphoric Acid (P_2O_5)	7·0
Chlorine	21·0

The chlorine in the above is just about enough to combine with the whole of the potash, and therefore the sample, which is a fairly representative one, contained nearly 50 per cent. of its weight of chloride of potash.

An elaborate series of field experiments was carried out at Dacca in the monsoon season of 1916 with jute as a test crop.

The results, which entirely confirmed others obtained in the previous year, showed that up to 94lb. potash (K_2O) per acre, with lime, applied to acid laterite soils in Bengal, produces a remarkable effect on the yield of jute, causing an increase over the controls of about six maunds of fibre, worth Rs. 50 per acre. Approximately the same result was produced by equivalent amounts of potash in rotted hyacinth, hyacinth ash, carbonate of potash, and chloride of potash, and the tests leave no doubt that the remarkable increases obtained are due to the effect of potash in the presence of lime. It is fortunate that the portions of Bengal in which water hyacinth occurs are included among the heaviest jute-producing districts in the province. On the other hand, the inhabitants of those tracts have now a powerful incentive to prevent the hyacinth from seriously encroaching on the water communications of the districts affected.

Conclusions.

(1) 500 maunds (40,000 lb. or about 18 tons) of the green plant per acre will supply the following approximate amounts of plant food :—

Nitrogen	20
Potash (K_2O)	80
Phosphoric Acid (P_2O_5)	35
Lime	60

(2) It is well to remember that in the green state water hyacinth is extremely bulky and contains about 95 per cent. of water. It could not therefore be economically transported over any considerable distance.

(3) The rotted material is also bulky, being comparable with farmyard manure, except in regard to its content of potash which is several times greater. It is probable that transport difficulties will prevent the use of rotted hyacinth at any great distance from its place of production.

(4) In preparing the rotted material the green plant should be partially dried before stacking; otherwise a lot of liquid is exuded during the rotting process which causes a very serious loss of valuable material, amounting in one instance to 75 per cent. of potash.

(5) The dried plant is only about one-twentieth of the original green weight and is therefore in a much more convenient form for transportation. It contains from 1·5 per cent. to 2 per cent. of nitrogen and from 20 per cent. to 25 per cent. of ash including about 8 per cent. of potash (K_2O).

(6) The ash is only about one-hundredth of the original green weight, and it contains all the valuable mineral constituents in an easily available form; but of course all the organic matter and the nitrogen are lost in the burning. Several samples of ash from plant* obtained from different parts of the Dacca District have contained nearly 50 per cent. of chloride of potash, in addition to appreciable quantities of phosphates and lime.

Messrs. Shaw, Wallace & Co., of Calcutta, have offered to buy any quantity of hyacinth ash at Rs. 4 per unit of potash (K_2O) landed in Calcutta. This is equivalent to from about Rs. 84 to Rs. 120 per ton of the ash.

* An extensive series of analyses recently made indicates that the potash content of Water Hyacinth varies within wider limits than those given above. For instance, some samples of plant ash taken from *khals* in Dacca city and Narayanganj have been found to contain as much as 35% of potash (K_2O). This plant was about 3 feet high and very vigorous On the other hand, the ash of plant from poor red soil districts contained as little as 11% potash. This plant was stunted.

The ash of a sample of Water Hyacinth sent by the Director of Agriculture in Madras contained 18% potash.

(7) Through the influence of Mr. Hart, Collector of Dacca, about 150 Presidents of Panchayets in the Dacca District were enabled to visit the Dacca Farm to see the field tests already discussed. In consultation with Mr. Hart leaflets in English and Bengali have been drawn up, and 1,000 of the former and 10,000 of the latter have been distributed in the Dacca District.

(8) There are already indications in the Dacca District that the cultivator is beginning to appreciate the agricultural possibilities of water hyacinth: there is also reasonable ground for belief that in a densely populated tract where the plant can be put to such good use as it undoubtedly can be on a valuable staple crop like jute, the people will in the course of time solve the problem for themselves.

DRY-FARMING METHODS IN MYSORE *

BY

A. K. YEGNA NARAYAN AIYER, M.A., N.D.D., F.C S.,

Deputy Director of Agriculture, Mysore.

I. INTRODUCTION.

THE term "Dry-farming" is of American origin and was brought into current usage by Mr. H. W. Campbell of Nebraska, U. S. A., who claimed to have discovered a special form of soil tillage suited to regions of poor rainfall. During the last ten years the subject has been so much boosted in the typical American manner, under the support, it is said, of powerful railroad and other interests, that one would have thought that a new science had arisen. In 1911, however, Doctor J. A. Widtsoe's book on dry-farming appeared and presented a much more sober view of the subject and laid stress also on the limitations of these methods. In the summer and autumn of 1911, it was my privilege to visit in the course of my travels in the United States, several dry farms including that of Mr. H. W. Campbell, and dry land investigation stations including that of Utah, to attend the Dry-farming Congress and to interview scientific workers in dry-farming methods, like Dr. Chilcott of the Washington Department of Agriculture. After a close acquaintance with the Mysore agricultural methods, one cannot help calling to mind the observations made by the late Professor F. H. King of Wisconsin after his tour in China, *viz.*, that at every step he wondered how the farmers of that country were showing in their agelong every-day agricultural practice, how well they understood the principles established by him only by laborious and long

* A paper read at the Fourth Indian Science Congress, Bangalore, 1917.

continued research. In Mysore the story is somewhat similar, and I give in the following pages a very brief account of the dry-farming practices of this State which will show how well the Mysore ryot has understood these principles.

II. Mysore dry-farmed areas, their extent and the meteorological conditions therein.

The expression "Dry-farming" has been defined as the raising of successful crops without irrigation in regions where the annual rainfall is less than 20 inches, or if the moisture-dissipating agencies are severe, in regions of rainfall even up to 30 inches. The Mysore State is pre-eminently a dry-farmed country, for the total area under unirrigated cultivation is over 5 million acres or over 80 per cent. of the total area under cultivation. So far as the rainfall is concerned, out of the 77 taluks which constitute the State, 5 have only less than 20 inches, 16 have between 20 inches and 25 inches, 29 have between 25 inches and 30 inches, and the remaining with an area of 1½ million acres, or 23 per cent. of the total, have a rainfall over 30 inches. The mean daily temperature in these tracts is about 75° with a maximum of 85° and a minimum of 65°, while the humidity averages 59 per cent. During the greater part of the year, the country is swept by winds the mean velocity of which taken throughout the year is about 130 miles.

The evaporation measured over a free surface of water amounts on the average throughout the year to a total of from 72 inches to 100 inches in Bangalore, where the average yearly rainfall is 36 inches. Furthermore, years of scanty rainfall or unfavourable distribution even if the rainfall is up to the average, are not infrequent, giving rise to partial or total failure of the dry crops. Thus taking the rainfall in one of our dry districts, *viz.*, Chitaldroog where the average rainfall has been 25 inches, in the 16 years' period from 1899 to 1914, during 8 years it has dropped down to 15, 14, 21, 16, 15, 19, 16, and 17 inches.

The areas specified as under dry cultivation can therefore with reason be said to be "dry-farmed" in accordance with the definition

with which we set out. Successful agriculture has of course been carried on for centuries on these areas and we shall now look into the methods.

Now, what is successful dry-farming ? It is in essence the utilization of the scanty rainfall to the greatest advantage. Such methods of tillage are adopted as will receive all the rainfall into the soil and retain it there for the use of the crop, safe from the drying action of the sun and winds and weeds ; the sowing of such crops as can be successfully matured even with scanty moisture in the soil ; the sowing of the same by such methods as will not only give the seeds and the young crop the best chance but also facilitate interculture ; and the systematic carrying out of this same interculture by means of implements best suited for the purpose.

III. American Practices and Recommendations.

The first of these aims is to be attained, according to the American writers mentioned above, principally by cropping only every alternate year, the fallow year being given over to clean tillage, which according to Mr. H. W. Campbell, is to be effected by ploughing the soil immediately after harvest, by compacting the sub-soil with a sub-surface packer and by keeping the top-soil frequently harrowed so as to preserve a permanent mulch, so that during this fallow year the soil may absorb and retain as much of the year's precipitation as possible. There is, however, no great support for these recommendations of Mr. H. W. Campbell. According to Dr. Widtsoe, except in regions where the rainfall is less than 15 inches, there need be no fallow every other year especially if the cropping season coincides with the rainy season, and, according to Dr. Chilcott, there need be no fallow year at all if a suitable rotation involving the growing of a hoed crop is followed. As regards the sub-surface packer which is Mr. Campbell's original idea, very few people in the States seemed to believe in it. In the session of the Dry-farming Congress which I attended, the matter was treated with indifference. Even in Mr. Campbell's own farm, although it was a model of clean tillage, I could see that the neighbours had a better stand of corn than was to be seen in his fields.

IV. MYSORE DRY-FARMING PRACTICES.

In Mysore the same effect is striven after thus :—

1. Impounding rainfall.

Firstly with regard to receiving the rainfall into the soil. In all the eastern districts of Chitaldroog, Tumkur, Kolar, and Bangalore, it is not an uncommon sight to see dry land fields carefully bunded round so as to make the rain-water remain on the field for quite a considerable time and soak into the soil. Such bunds are also provided with little miniature weirs for the overflow of the water. In the black cotton tracts these bunds attain quite 4 or 5 feet in height. In the taluks of Tiptur and Chiknayakanhalli there are extensive shallow valleys in which splendid coconut plantations are raised on the *khushki bagayat* or dry land gardening system. On these areas the method of bunding up and thereby impounding the rain-water is practised invariably and in fact, but for this method, it would be impossible to raise these plantations, for the rainfall there is less than 25 inches and the tract is not thought much of even for the ordinary dry crops.

2. Ploughing after harvest.

In addition to the impounding of rain-water by this means, the soil itself is left in a ploughed up condition to absorb the early rains thoroughly. Ploughing of this kind commences really immediately after the harvest of the main monsoon crop. Great importance is attached to this practice and in certain sections of the State it is systematically carried out under the name of *kar ula* or *bellukke* or *maghi* ploughing. This is practised notwithstanding the fact that the field is at the time occupied by a standing crop of *avare** or *togare,*† one of the mixed crops sown in rows about five feet apart at the time of *ragi* (*Eleusine coracana*) sowing. In the eastern districts, however, this practice is not so common, although its beneficial effects are appreciated and valued even more. The importance of opening up the soil before the commencement of the hot weather and allowing it to weather through these months is realized so well indeed that in these districts careful ryots go to great pains and expense in carrying out this difficult operation. Especially is this the case

* *Dolichos Lablab.* † *Cajanus indicus.*

when in the subsequent season the crop to be raised is a money crop such as tobacco or chillies. In the Chitaldroog dry tracts, I have seen the ryots breaking up the hard baked red loams, characteristic of this State, with a heavy wooden plough weighted with stones and drawn by two pairs of strong bullocks. I have seen land equally hard and foul with weeds also being worked with an ordinary wooden plough although at that time little more than a scratching could be given. The fields are given repeated ploughings and harrowed later on with the bladed *kunte* so that prior to the planting of these crops an excellent clean and mellow tilth is produced. In the coconut plantations I mentioned above, immediately after the north-east monsoon ceases, ploughing begins and is repeated according to established custom six times during the season preceding the south-west monsoon.

Results and explanations of ploughing after harvest.

The results of such practices are indeed striking, for in experiments at the Hebbal Farm, the yield of *ragi* on plots ploughed after harvest has been almost twice the yield on plots not so treated, and as far as the ryots are concerned, though obviously there can be no such numerical records, their faith in it is sufficient proof of its value. It would be interesting to know how this result is brought about. Is it that the stirred soil forms a mulch protecting the moisture in the lower layers of the soil from rising to the surface and being lost by evaporation? Or that the ploughing prevents the loss of soil moisture merely by the destruction of weeds? Is it again only a preparation of the soil to absorb the first rains fully? Or is it that various chemical changes are induced tending to increase the fertility? As regards the soil moisture I may refer to some of the experiments on soil moisture conducted under the direction of Dr. Lehman, late Agricultural Chemist to the Government of Mysore. Some of these experiments are referred to and commented upon in the Annual Report of the Department for the year 1906-07. The scheme was to determine the soil moisture up to a depth of six feet in sections of $1\frac{1}{2}''$ to $3''$ up to the first foot and in $6''$ sections lower down on plots treated in various ways such as plots left rolled to

imitate unploughed ground, plots partly stirred to different depths, *viz.*, $1\frac{1}{2}''$, 3″, 6″, and 18″, and plots growing different crops. The general results of these moisture determinations were firstly that the increased storage of moisture due to the protective mulch was comparatively small, at any rate not high enough to be directly responsible for any increased crop yield; secondly, that a soil mulch of 3″ was almost as effective in this regard as those even 18″ deep; and, thirdly, that the drying effect of even a poor crop was remarkably high. Experiments on ryots' fields similarly showed little difference in the moisture contents of soils which were not ploughed soon after harvest and those which were left ploughed after harvest. Furthermore, it was also noticed that even when the top 6″ or 9″ soil was quite dry, containing practically little more than its hygroscopic moisture content, the soil below was quite moist and contained as high as 8 per cent. to 14 per cent. of moisture. In one case indeed, the sub-soil water (or water table) was at a depth of 18″ below ground, while the top 4″ was so hard and dry that I found it well nigh impossible to drive the soil-sampling implement through. The inference may therefore be drawn that the capillary rise of water evidently is much too slow compared with the intense drying effect of the climate and that once the top layer becomes quite dry, it acts as a sufficiently effective mulch irrespective of whether it is stirred or compact. Were conditions otherwise, it is hard to conceive of the existence of any moisture at all in the lower layers of the soil in this country, which both these determinations and common experience show to be present more or less to the extent indicated. Reference may also be made in this connection to a controversy regarding the rise of soil moisture in Indian soil between Dr. Hall, late Director of the Rothamsted Experimental Station, and Dr. Leather, late Agricultural Chemist to the Government of India. Work outside India tending to the same conclusion is admirably discussed and summarized in pages 147 *seq.* of Dr. Widtsoe's book on dry-farming. Where, however, as in the coconut plantations referred to, the ground is shaded profusely and the drying action is not so severe, the protective action of the mulch of ploughed soil does really operate. For the ordinary dry land soils then we shall have to

ascribe the beneficial results of this ploughing partly at least to other causes. It may be nitrification, for when the soils weather through the early rains at least there will be enough moisture for this process to gc on ; it may be "soil heating," for in the black cotton soils the surface becomes too hot to walk with bare teet ; or it may be a case of the setting free cf soluble plant food. The ryot himself looks upon this ploughing as tantamount to manuring and expresses this sentiment in the saying that this ploughing is the poor man's equivalent to the rich man's manuring.

Leaving this fertile field of research to the chemist and the soil bacteriologist, I proceed to the next link in the chain of operations. The subsequent operations are either repeated ploughings or harrowing with both the heavy and light bladed harrows, the removal of stubble and dry weeds, levelling with the plank and light harrowing with either a light bladed harrow or a bamboo spike tooth harrow. A remarkably fine and clean seed bed is then secured ; we may also note that if there should be a shower at this stage or soon after sowing, which beats down the mulch. it is forthwith restored by the use of the bamboo spike harrow.

3. Selection of seeds.

Coming next to the kinds of crops sown there are shallow-rooted cereal crops, deep-rooted legumes or oil-seed crops, and early maturing grain crops, each helping in its own peculiar way the raising of successful crops under dry farm conditions. We may observe that some of these dry land grains are practically the hardiest known so far as drought resistance is concerned. Although they respond well to optimum water content in the soil, it is wonderful that with a soil moisture content of even 4 to 8 per cent. round the root range of these crops, a respectable crop can be raised.

Considerable work remains to be done on the water requirements and the degree of drought resistance of these different crops, but according to the ryots, among the grain crops, *haraka* (*Paspalum scrobiculatum*) will be hard to beat as a drought resistant crop. A small area of this is usually put down every year by a large number

of ryots. In crops such as *baragu* (*Panicum miliare*) the ryot finds a quick growing though poor yielding grain crop to take advantage of even a bad season. The system of mixed cropping though followed primarily for the purpose of raising a variety of crops, on limited holdings, should still be looked upon as a device to take advantage of both the surface moisture of a good year and the deep underground moisture of even ordinary years; for the *akkadi* or mixed crop chosen is a deep-rooted crop such as *avare*, *togari* or cotton, while the main crop is a shallow-rooted grain crop. It is rarely indeed that both crops fail and therefore by not putting all his eggs into one basket, the dry land farmer really dodges the drought. In the extreme eastern taluks a number of ploughings throughout the south-western monsoon prepares the ground either for the cheap grain *navane* or one of the later sown pulses like horse gram.

4. Sowing methods.

Coming next to sowing methods, sowing in rows can be said to be the rule, the exception being where owing to the wetness of the soil the drill may not be used for fear of the drill holes becoming choked, although even in such cases, intelligent ryots use a drill of special type to get over this difficulty. The sowing in rows is effected in various ways. Firstly, there are drills of various patterns which differ not only in the number of rows, *viz.*, from 2 to 11, which they sow, and in the intervals between the rows from 4" to 3', but also in the method by which the seed is dropped into the furrows. Secondly, furrows are made by a plough at regular intervals and into these the seeds are dropped through a *sadde* tied behind this plough or dropped by hand right into the furrow itself. Thirdly, furrows ordinarily three in number are drawn with a special three tined cultivator, and in these furrows seed mixed with manure is put in continuous handfuls. Fourthly, furrows are drawn either by the plough or by a cultivator lengthwise and crosswise at regular intervals so that the field is laid out more or less into squares like a chess-board and at each intersection of the furrows either seeds are sown by

hand or seedlings transplanted. These sowing methods facilitate thorough interculture with bullock implements, these implements being of various patterns and sizes to suit the nature of the work to be performed and the width of the space between the rows.

But before passing on to these interculturing methods, attention may be drawn to the curious practice of mixing manure with the seed, somewhat similar to the drilling of artificials. This is usual with *jola** and with *ragi* and of this latter the seed is mixed with manure in the proportion of a seer to a cart-load. Whether such thin seeding with plenty of nourishment for the young plant close to its roots results in a better and a more assured yield than the other method can be made out only by comparative field trials; but how almost identical it is with the recommendation contained in the text-books on dry-farming regarding thin seeding and manuring is a point worthy of note.

In some taluks, notably in Nagamangala and neighbouring tracts, soon after the sowing of *ragi*, a flock of sheep is driven round and round the field until the soil becomes compacted, helping to bring the moisture up round the seeds and favouring germination. Curiously enough this is not followed by harrowing with the brush or bamboo light harrow so as to restore the mulch on the top and retain the moisture near the seeds.

5. Interculture

Coming now to interculture, it may be said that careful and elaborate interculture is recognized in the State as the essence of dry-farming. There is a goodly variety of implements, both hand tools and bullock implements, each designed admirably for the kind of work intended. These after-operations have for their object the thinning of the crop, the destruction of weeds, the production of a soil mulch, the earthing up of the rows or the opening up of shallow furrows close to the rows. Thus in the case of *jola* or castor the interspace is ploughed up, in the former along the length of the rows, and in the latter both lengthwise and breadthwise. This has the

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* *Sorghum vulgare*

effect of both earthing up the plants and also of making rain-water stand close to the rows of plants. Other interculturing tools are of several patterns, all, however, conforming to a general type, *viz.*, that of a small log of wood to which is attached either one row of teeth or an entire flat blade, the log or beam being provided with a handle and a couple of long poles for carrying the yoke. Of these hoes there are at least ten styles in use in the districts. Some with teeth or spikes or flat hoe blades are of one type and those with entire blades are of a different type. Whatever tools may be used, interculture begins as soon as the rows of crop begin to show above ground. In most cases the toothed hoes are worked lengthwise and crosswise which thins the crop to almost a quarter and kills the young weeds. In the case of the bladed harrows, these work only between the rows but are remarkably efficient. They cut or uproot the young weeds and also work the whole width of the interspace without choking. They are made of different sizes to suit different widths of the interspaces. Interculture is held to be so important, for it is found that failure to do it in time owing perhaps to wet weather or other causes results in a set-back from which the crop never recovers. The interculture is repeated about four times and then when the rows close up hand-weeding begins. In the typically dry-farming areas these implements are worked in batches, two or three of them being hitched to one and the same pair of bullocks.

V. Other important features of dry-farmed areas in Mysore.

The other features of the dry-farmed areas are also of interest. The holdings are comparatively large and the implements are also such as to handle this large area in a short time. The fields too are very large, some more than ten acres, so as to admit of these comparatively large implements. The ploughs and harrows are also very heavy and are made to work deep. The plough bullocks are also much larger and heavier than those to be seen in other tracts and are tended with great care. There is such a variety of implements and appliances in these tracts that it will surprise observers used to only wet cultivated tracts.

Similarly again these dry land tracts are also the districts of well cultivation ; for it is realized how difficult it is to obtain assured and remunerative crops by dry-farming alone and practically all the large irrigation wells in the State are situated in the area of four eastern districts.

VI. Conclusion.

From the foregoing account it should not be understood that the practices described are observed throughout in all the villages. Either owing to want of knowledge or conservative custom there are a great many villages in which they are not in vogue, and in a transference of the good practices of the better class villages to others where they may be suitable also, lies much opportunity for good work.

AGRICULTURAL INSURANCE *

BY

RAJAMANTRAPRAVINA DEWAN BAHADUR
J. S. CHAKRAVARTI, M.A., F.R.A.S.,
Controller and Financial Secretary to the Government of Mysore.

THE subject of agricultural insurance in India has been under my study for the last three years. A few conclusions arrived at by me in the course of this study were published in a series of papers in the *Mysore Economic Journal.* The favourable reception accorded to these articles in all parts of India has further impressed on me the importance of this subject.

The subject is intimately connected with three sciences, *viz.*, economics, meteorology, and agriculture. A thorough study of each of the three aspects is absolutely necessary for a satisfactory solution of the whole problem. The main object of this little paper is to discuss that aspect of the subject which is intimately connected with Indian agricultural conditions. It would be of the greatest advantage to know whether Indian agriculture satisfies those conditions which are necessary for making any scheme of agricultural insurance practicable. If my paper succeeds in eliciting an expression of opinion from the eminent authorities on Indian agriculture assembled here, my object in bringing the subject before the Congress will be gained.

The contract contemplated in the system of agricultural insurance which I have developed, stated in its simplest form, is as follows :—

If the aggregate rainfall measured at a certain raingauge in a certain specified period or periods of the agricultural year be less

* A paper read at the Fourth Indian Science Congress, Bangalore, 1917.

than a certain number of inches, then for each period of deficiency a certain sum of money will be paid by the insurer to the insured in respect of the insured fields as compensation. The determination of the variable factors of this contract requires a very thorough and careful study of the meteorological, economic, and agricultural conditions of the area under consideration.*

The particular aspect of the problem of agricultural insurance with which we are now concerned involves a discussion of the following questions :—

(*a*) Under Indian agricultural conditions will a scheme of rain insurance practically serve all the purposes of agricultural insurance ?

(*b*) Can any periods be marked off in the Indian agricultural year, the quantity of rainfall in which by itself will practically determine the success or failure of agriculture for the year ?

(*c*) What percentage of deficiency in the normal rainfall should be regarded as a minimum limit for insurance purposes ?

As regards the first point I have arrived at the conclusion that in many Provinces and States of India most of the objects of agricultural insurance *can* be attained by a simple system of rain insurance. Indian agriculture is dependent almost entirely on rainfall. The so-called dry crops depend directly on rain, and of the wet crops a considerable part depend on tanks or other works which, while they are useful in storing and seasonably distributing the year's rainfall, would themselves fail in seasons of drought. The percentage of agricultural land that can be effectively protected against severe drought by irrigation works of large magnitude is

* For example, after full study it has been made out that in Mysore the contract will be somewhat as follows :—If a ryot insures his fields for any year by paying an annual premium equal to the land revenue assessment on such fields and if the rainfall at the headquarters of the taluk, in which the insured field is situated, from 1st January to 31st July in that year is in defect of the normal as specified in the contract by more than 35 per cent., compensation equal to four times the annual premium will be paid in respect of the insured fields. A similar compensation of four times the annual premium will also be paid if the rainfall from 1st January to 31st October is in defect of the normal as laid down for that period by more than 35 per cent.

small. In these circumstances, the quantity of rain during the year and its distribution as regards time are almost the only essential factors which dominate Indian agriculture. Of all the acute and chronic dangers to the crops of the cultivator in different parts of the world, *viz.*, damage by insects, diseases of plants, earthquakes, landslips, waterspouts, hail, inundation by sea or rivers, frosts, floods, long continued cold, cloudy weather, irregular seasons, deficiency of rainfall, excessive rainfall, the risk due to the last two alone is far more important to the Indian agriculturist than that due to all the other causes put together. Of the two causes connected with rainfall again, the effects of drought or deficiency in rainfall are far more important and extensive factors in agricultural operations than the occasional dangers caused by excessive rain. In short, if the Indian agriculturist can count upon the fact, *viz.*, that the rainfall in his locality will not be below a certain number of inches by a specified date in the agricultural calendar, he is practically assured of having a crop not differing much from the normal standard.

It may be freely admitted that rain insurance is not *exactly* identical with crop insurance. Causes of crop destruction other than drought will remain unprovided for. As raingauges cannot be fixed on every field, practical action will have to be taken with reference to comparatively large area units and the inequalities within the same unit will have to be ignored. The compensation to be paid in case of a specified degree of deficiency in rainfall cannot be assessed on the actual loss in each case, but will have to be roughly fixed with reference to some such data as the average yield or assessment paid on the fields. But most of the other factors which injure the cultivator's crops are such as he himself can prevent or counteract by his own exertions. An efficient agricultural department—almost all Provinces and important States have got such a department now and development in this direction is receiving the earnest attention of all Indian administrators—can be of very great help to the cultivator in this respect. It is only the rainfall factor which is uncontrollable by human exertions. As there is no way at present of preventing this uncertainty the only course

left open is to mitigate its effects by the scientific application of methods relating to uncertainties and risks. Of course the deficiency of rainfall on each field and its effect in the shape of agricultural loss cannot be accurately measured and compensated. But the question is whether a scheme of rain insurance as sketched above will not meet the requirements of a great majority of cases.

As regards the second point it appears on careful study that in most parts of India there are periods in the agricultural year, the quantity of rainfall during which practically determines the prospect of agricultural operations for the year. These periods of course vary from one agricultural area to another. In some areas there may be one such period; in others where the variety of crops is considerable the periods may be two or more. For the Mysore State after a detailed investigation and a close study of the life-history of various crops I have come to the conclusion that there are two such periods, *viz.*, May to July and August to October. The quantity of rainfall during each of these periods may be regarded as determining the crop prospects of the Mysore State. The distribution of rainfall within each of these periods, of course, affects the crops to a certain extent, but by dividing the period from May to October into two parts, it is for all practical purposes possible to regard the *quantity* only as the determining factor. The introduction of the element of distribution within the period under consideration will complicate matters to such an extent as to make an insurance scheme unworkable. Of course the distribution factor is taken into account in determining the risk-fixing periods themselves within the agricultural year.

As regards the third point, namely, the minimum limit of insurable deficiency in rainfall, it is not possible to arrive at a common limit applicable to all areas and under all conditions. The total quantity of rainfall in the area under consideration is an important factor in this respect. A deficiency of 35 per cent. may be fatal in places where the annual total rainfall is from 15 to 20 inches; it may not be a serious thing in places where the rainfall is between 60 and 100 inches. The nature of the crop is also important as some crops can bear deficiency better than others. The distribution of rainfall

is also material. A deficiency at the critical periods in the life of crops is much more serious than a deficiency at other periods. But when all this is said it may yet be possible to arrive at a percentage in respect of each homogeneous agricultural area so that if the total rainfall in the risk-fixing period or periods is deficient by more than that percentage then the agricultural conditions would be so materially affected as to make insurance relief necessary to the cultivator. For the Mysore State after detailed consideration I have found this limit to be about 35 per cent. It has been found that on this basis there would be on an average a failure in one of the two risk-fixing periods of the year once in four years.

Of course in the actual realm of facts there is no sharp demarcation between an immaterial degree of shortage in rainfall and a material degree of deficiency for which compensation is necessary. From a trifling deficiency of, say, 5 per cent. to a severe drought involving a deficiency of over 50 per cent. below the normal, there are all degrees of deficiency, and it is not possible to say that no loss results up to a certain limit of deficiency but that beyond that limit considerable loss arises. For purposes of working an insurance scheme of this kind, however, we must draw the line somewhere. In cases where the deficiency is just less than the percentage we fix, there will be some loss for which no compensation will be paid. In cases where the deficiency falls on the other side of the line the amount of compensation given may be somewhat in excess of what the actual loss demands. But there can be no doubt that if we fix the percentage carefully and after detailed study it will work fairly and justly on the whole both to the insurer and the insured.

If the three questions referred to above can be satisfactorily answered by authorities on Indian agriculture on the basis of a scientific study of facts and figures, a material step in advance will be gained in the solution of the important problem of Indian agricultural insurance.

I have here stated very briefly and in general terms those points connected with the agricultural aspects of the problem which may

be profitably discussed. The results of the detailed study which has led to the formulation of a concrete scheme for the Mysore State have not been given. Nor have I referred to the various interesting questions connected with the economic and meteorological aspects of the question. If the subject is taken up and discussed, such additional facts as may be required by those interested will be placed before them.

SOME EXPERIMENTS IN THE IMPROVEMENT OF THE DATE-PALM SUGAR INDUSTRY.*

BY

H. E. ANNETT, B.Sc., F.I.C.,

Agricultural Chemist to the Government of Bengal.

IT is not generally realized, I think, how important palms are as a source of sugar in India. India produces some hundreds of thousands of tons from this source per annum. A really accurate estimate is difficult to make, but I am convinced that 10 per cent. of India's home-grown sugar is produced from palms. During the past few years I have been able, from time to time, to devote some time to studying the industry. Most of my work has been done on the wild date-palm, *Phœnyx sylvestris*, which is the common sugar palm of Bengal. A general survey of the industry and of my earlier work was published as a Memoir of the Department of Agriculture in India (Chemical Series, Vol. II, No. 6) entitled, "The Date Sugar Industry in Bengal." More recently I have been able again to do some more work on the subject and the results of this work are about to be published. Mr. Mackenna has, however, asked me to communicate a paper to this Congress and I propose to refer briefly to some of the results I obtained from efforts directed to discover improvements in the industry.

In the first place, we will deal with the effect of various methods of juice collection.

In Madras, where the palmyra palm is the chief sugar producer, lime is in general use as a means of preventing fermentation of juice in the collecting pots. In Bengal lime is never so used but the people

* A paper read at the Indian Science Congress, Bangalore, 1917.

prepare their pots for juice collection by placing them mouth downwards over a smoke fire. They claim that the smoke helps to preserve the juice.

In North America the maple tree is tapped to some extent for sugar and of recent years metal pails are in use there for juice collection.

In my work I designed experiments to test these various methods of juice collection. In addition I also tried the effect of using small amounts of formalin in the pots as a preservative. Thus the following methods were under trial :—

(*i*) Earthenware pots without any treatment.
(*ii*) Earthenware pots smoked in the cultivator's way.
(*iii*) Earthenware pots coated inside with lime.
(*iv*) Earthenware pots washed out with small amounts of formalin.
(*v*) Metal buckets as used in North America.

The juice from a number of trees was collected by each method over a period of some three weeks. The juice from each series was analysed daily both for saccharose and reducing sugars. The complete data obtained are to be published elsewhere but the results were quite definite and showed—

(*i*) That smoking the pots does have a distinct effect in preserving the juice.
(*ii*) That formalin has a similar effect but the effect is very variable and hence the use of formalin is unreliable.
(*iii*) That metal buckets are very unsatisfactory. More often than not juice collected in this way was the worst of the whole series. This result is difficult to understand.
(*iv*) That the use of lime gave excellent results and this practice is to be strongly recommended. It gave easily the best results of the whole series.

It is further to be noted that in Bengal under present conditions most of the juice which drips from the trees in the day time is not collected because it is so badly fermented that the people cannot

get crystalline *gur* from it. Our experiments showed, however, that if the practice of liming the pots be introduced then this day juice can all be used for *gur*-making. We always succeeded in getting excellent *gur* from this day juice which had been collected in limed pots. Hence we have here a possibility of largely increasing the yield of *gur* from a given number of trees. We ought to point out, however, that during the day the juice flows much more slowly than at night. Numerous measurements show that the day juice represents only about one-fifth of the total juice flow during the twenty-four hours. Even this amount is worth while collecting especially as its sugar content is considerably higher than that of the night juice.

We might explain that the good effect of the lime is due to the fact that in addition to being a good sterilizing agent for living organisms it also prevents the action of the enzyme invertase.

The next point I propose to deal with is the colour of the date-palm *gur*. To any one acquainted with date-palm and cane *gurs* the very dark colour of the former is well known. In fact its dark colour is one of the reasons why palm *gur* is not very popular for eating purposes. It has been said by some that the colour could be improved by boiling the juice in iron pans, for at present practically all palm *gur* is made in earthen pans. Our experiments showed that iron pans did not markedly improve the colour. We have found, however, that date-palm juice when fresh is strongly alkaline to litmus. It is well known that when alkalies are boiled with reducing sugars dark-coloured bodies are formed. Accordingly it seemed to us that the dark colour of these *gurs* might be due to the action of the hot alkaline juice on the reducing sugars always present. To test this point, we carefully neutralized a large volume of juice (about eight maunds) to litmus by means of citric acid. The result was very striking. On concentrating the juice no signs of darkening whatever occurred. By means of a thermometer we were able to tell when the liquid was sufficiently boiled. At this stage the liquid was a lovely pale light golden yellow and the local *gur*-makers would not believe the operation was finished. A nice light coloured *gur* was obtained. Sulphuric acid, hydrochloric

acid, alum, lemon juice, and extracts of tamarind fruits were tried in a similar manner. All these gave similar results. In the case of hydrochloric acid we did not get such good results especially with an excess of the acid. It is well known that hydrochloric acid on boiling with laevulose produces a dark red colour, and no doubt this is the reason why this acid did not produce such good results.

I will conclude with a few remarks on the question of fuel. In the case of cane-sugar, of course, the megass of the cane usually supplies the whole fuel required in the boiling process. In the case of the palm we have to make special arrangements for fuel. It is true that dried palm leaves stripped from the trees supply fuel for the first three weeks or so of the season but after that wood has to be used. The native furnaces are simply holes in the ground over which the boiling pans are placed. There is a hole into which the fuel is fed and an outlet for smoke, and smoke is also allowed to escape around the rim of the furnace hole on which the boiling pan rests. Sometimes only one pan, more often two, at times four, and I have seen as many as eleven pans, are placed over each furnace. We performed a number of careful measurements of the amount of wood fuel used by the people in making one maund of *gur*. Very interesting results were obtained. An average of a large number of tests gave the following results in maunds of wood required to make one maund of *gur*. With one pan on the furnace 9·8 maunds of wood were required; with two pans 8·6 maunds and with four pans 6·4 maunds of wood. It is therefore obvious that the man who has sufficient juice to boil four pans on one furnace can effect a considerable economy of fuel.

We tried the effect on fuel consumption of using a shallow iron pan over a furnace fitted with firebars and a chimney in order to give good underdraught. We were able to make one maund of *gur* with a fuel consumption of only 5 maunds of wood. We only performed a few experiments with this furnace but it seems clear that there is room for much economy in fuel consumption.

Selected Articles.

THE ECONOMICS OF A DECCAN VILLAGE.*

BY

HAROLD H. MANN, D.Sc.,

Principal, Agricultural College, Poona.

I.

AMONG the questions which those who are interested in the future of India must most frequently ask themselves are—How far is the condition of the rural population improving or the reverse ? and—How far are changing economic conditions in India affecting rural life both in its economic and agricultural aspects ? It has hence long been my ambition to try and ascertain by careful and close inquiry in a comparatively few rural centres in the Deccan what is the actual present condition of the people. I have wished to do so because I believe that it is only by such intense inquiry in a comparatively limited number of centres that these questions can receive an adequate answer. The publication of Mr. Keatinge's book on "Rural Economy in the Bombay Deccan" very markedly increased my wish to conduct such an intensive investigation as I have mentioned. In that book he drew, largely from his own personal experience in Deccan villages and largely from Government and other records, a considerable number of conclusions with regard to the condition and tendencies of rural life in this part of India. The reasons which he gave for these conclusions seemed

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insufficient, but the conclusions themselves seemed rather of a nature to stimulate further inquiries than to make one feel they could be accepted as they stand.

This being the case I undertook with the help of a number of my friends and assistants to conduct a survey of a single Deccan village, and wish to lay before the readers of this Journal a few of the more obvious results of my inquiries. Space will not allow of more than this, but those results which I can present will, I think, be found to be at least of a character to stimulate discussion and to add considerably to the data existing for an understanding of the condition of the rural population in this part of peninsular India.

Just one more point by way of introduction. The village which I shall proceed to describe represents one type only of the villages in the Deccan. It lies distinctly in the zone of fairly assured rainfall, and it is also a village in which practically no irrigation takes place. In order to get a full picture of village life even in the Western Deccan two other types of village would have to be considered, namely, that in which a village possesses a large number of wells for irrigation, and in which the prosperity or otherwise of the village depends on the existence of these wells; and that type of village which is a creation of irrigation canals, in which cultivation is rich with an intensity such as is hardly to be seen in any other large area in India. The Eastern Deccan again, with its different distribution of rainfall, the extreme uncertainty of its moisture, and the depth and heaviness of its soil, represents a different series of conditions which would need again a further and distinct investigation.

II.

The village with which I am to deal represents the dry cultivation of the Western Deccan. It is named Pimpla Soudagar and lies nine miles from Poona to the west, and about two miles to the south of the Bombay Road, separated from it, however, by the river Pawana. It was chosen for this inquiry for three reasons: (1) It was sufficiently near to Poona to make it possible for us to investigate it; (2) it was considered to be sufficiently far from

Poona to prevent the influence of an adjoining city being paramount in its life ; and (3) it was sufficiently small to make it possible for an outsider to get a clear idea of the village as a whole. The area of the village amounts to 1,065 acres. All is held under the ordinary *ryotwari* tenure of the Deccan. *Inam* rights, that is to say, the right of the whole or part of the land assessment, of 211 acres are held by private *inamdars*, while there is a charge to another *inamdar* against the revenue of the whole village dating from the commencement of British rule in the Deccan.

This village lies on the banks of the Pawana river and is typical of many hundreds. The bank of the river is rocky and on a rocky ledge, parallel with the river, lies the village site. The outer boundaries of the village on every side but one are also high, rocky and uncultivable or with very shallow and poor soil. Between the comparatively rocky river bank and the high land round the village lies a hollow filled up during many centuries with the black soil characteristic of the trap region of Western India. The depth of this soil depends on the level of the rock below the surface. Where the rock is far below, there the soil is deep ; where it approaches the surface, there the soil is shallow. Below the soil there is either hard rock or the *murum* which represents disintegrated rock and which is of very little use from an agricultural point of view. The depth of the black soil, however, is the feature which determines the agricultural character of any particular field in the village. Round the edge of the village area, as I have already said, the soils are shallow. Sometimes there is no black soil at all, and the material which exists for the growth of plants is the disintegrated trap rock or *murum* which represents one of the driest and most "hungry" soils I have ever seen. The main part of the village is better. The soil, though not rich, is retentive and capable, under ordinary conditions of rain, of giving fair returns with good cultivation. The rainfall amounts to between thirty and thirty-five inches per annum.

As I have already said, the village owes its existence to the rocky ledge on the banks of the river retaining the black fertile soil in the hollow behind, which has been deposited there by

long continued washing from the surrounding hills. As the hills are near, the soil is not—for black cotton soil—very heavy, for heaviness in soil in the trap area depends largely, if not entirely, on the distance to which it has been washed by water. The village derives its supply of drinking water from a long reach of the river which lies in face of it. As in so many other cases, the river current almost entirely fails after January in each year, but a ridge of rocks at the extreme east of the village causes the formation of a long pool which retains water throughout the year. The river being almost entirely composed of surface water is very soft, and if it escapes contamination higher up its course, forms an admirable drinking supply. Beyond this, the village contains twelve wells all of them with water which partially or entirely fails at least in April or May in each year. This being the case, the village is essentially one which depends on dry cultivation. Two or three of the wells are occasionally used for irrigated crops, and formerly even sugarcane was grown over a few acres every year. This has tended to disappear in recent years, though in the present season (induced perhaps by the present very high price of *gur*) several acres are again under the sugarcane crop.

The wells depend, as do most in the Deccan, on fissure water. They are a most doubtful and a very expensive speculation. If a well taps a fissure of perennial water, the fortune of the man who digs it may be made. If the digging either reaches no water (and at least forty per cent. of the wells sunk in the Deccan are failures) or only reaches water running for a few months in the year, it is a failure which usually ruins the man who undertakes it. Of the twelve wells in Pimpla Soudagar one only has a fairly constant supply, five have a supply which sinks to half its quantity in the hot weather, in four other cases the supply sinks to less than a quarter, while the last practically dries up each year in March, April, and May. Such a condition has not tempted the people to experiment further, and one cannot blame them. Five hundred rupees invested in a well, unless there is a greater probability of success than has hitherto been reached with the available appliances, would be nothing but a gamble.

As in all Deccan villages, the cutting up of the land by rush of surface water has been the cause of the ruin of a considerable area of the village land. The damage is obvious, and some at any rate of the land near the river round about where the *nalas* break through the rocky ridge which borders it, is so badly cut up as to be spoilt. More important, however, is the constant wash of surface soil in small quantity from the fields—against which, except in a few places where irrigation has been or is carried out, very few precautions are taken. The limitation of embankment to such sites and the almost complete abandonment of the rest of the land to surface wash is, I fear, characteristic of a very large area in Deccan villages similarly situated.

I have already stated that the village consists of 1,065 acres. Of this land 1,020 acres are held by various holders. The balance consists of roads, *nalas*, and the village site. The division of the village land can perhaps best be shown up by a table :—

Total area of village	1,065 acres.
Area kept for public purposes	44 ,,
Area held by private owners	1,021 ,,
Area held for cultivation	1,006 ,,
Area fallow in 1914	91 ,,

This table at once indicates the characteristics of cultivation in a Deccan village. Its features are first the very large area held for cultivation and hence assessed which is not actually cultivated in any year and which only bears a very thin crop of grass and is used as inferior grazing. The existence of a large fallow area is very striking and shows how modern methods of maintaining the fertility of land have hardly reached the outlying unirrigated villages in the Deccan.

III.

As in all *ryotwari* tracts the revenue assessment of all the land goes direct to Government unless a definite grant to some one else, that is to say to an *inamdar*, has been made. The history of the growth of such grants in the later Maratha period is very interesting, and in the present case we have been able to trace it from 1,699 to

the present day. At various periods these *inam* grants were as follows :—

	1699 acres	1770 acres	1779—1819 acres
(1) For temples	84	84	84
(2) For village *Patel*	42	42	42
(3) For village *mahars*	28	28	28
(4) For individual *inamdars* . ..	84	112	112
(5) For village *Kulkarni*	..	..	12

The origin of the first or temple *inam*, devoted to a well-known temple in the adjoining village of Chinchwad, is a very old one and we have not got any record of it. Of the others only one now remains in its original form, namely, that for the *mahars*. The total area of the *inams* has been reduced and only 211 acres now remain under this privileged tenure. Only 35 per cent. of the ordinary assessment is payable by the holders of these lands.

In 1819 a new factor was introduced in the grant to one man, who had assisted in the British occupation, of the whole government revenue of the village for his own life and his sons, and then of half of it to his heirs for ever. The original grantees wasted their substance and by mortgage or otherwise the actual amount received had sunk from Rs. 910 to Rs. 211 by 1840. In 1856 the grant was converted into a definite money payment, based on the revenue in 1817-18, and this is now distributed among six members of the family. This *inamdar* is thus in no sense a landlord—he is merely a person who has a definite money charge against the revenue of the village.

IV.

The history of the land revenue of this village is very interesting; and previous to the coming of the British it affords a very striking record of the disturbed state of the country. The actual amount of revenue obtained and the expenses at different dates are shown as follows :—

	1770 Rs	1791 Rs	1797 Rs.	1811 Rs	1829 Rs.
Assessed revenue collected	801	792	1,087	1,158	889
Expenses ..	74	202	697	310	186
Net revenue ..	727	590	390	848	703

Nothing could illustrate in a more striking manner the increase of leakage of revenue during the later periods of the Maratha rule.

The revenue assessed and collected was higher by 45 per cent., but the amount actually received by the Government was exceedingly variable. New local officers like the *deshmukhs* (of whom there were two) and *deshpandes* made a charge on the village revenue, the village officers took much more than their *inam*, the extra expenses charged increased enormously. In one year (1791) which I take as an example, the expenses charged against the Government in the records include *solatia* to Government officers, festivities at the time of visits of officers and others, money spent on wandering groups of *gosavis*, and large amounts for which details are not even given. As far as one can judge, it would appear as if at least about Rs. 85 from the Government revenue was paid in moneys to greedy local officials of one sort or another beyond fees which they seem to have been entitled to charge. The extreme of this leakage is, however, seen in 1797 when out of a revenue of Rs. 1,087 only Rs. 390 reached the treasury. We do not know how much the people themselves were compelled to pay, but the time was that of the passage of the marauding armies of Shinde and Holkar. These leaders charged the village revenue with Rs. 179, and demanded a feast to their officers costing Rs. 14. Beyond this, presents to the messengers who brought the news of the Peshwa's Court were thought to be legitimate charges against the Government revenue. Finally we get a glimpse of the unsettled condition of the countryside in the fact of money paid to a village servant who did not get his usual fees on account of a riot.

In 1811-12 conditions were a little better, but the local leakage of revenue continued on an even greater scale than before. The assessment was higher, and the amount collected higher, and reached a maximum in 1817-18 when Rs. 1,226 were collected, an amount which fell to Rs. 889 ten years after British rule was established. After this we enter the modern period, the time of regular settlements and regular revenue returns. The actual figures for three dates are as follows:—

	Rs.
1849-50	1,115
1886-87	1,128
1914-15	1,660

We have thus a large increase in the land revenue during the later Maratha period, some reduction in the early British period, followed by a large rise. The gross amount now obtained for Government from the village is almost exactly double what was obtained in 1770. This does not mean that the assessment on the land is double, as some of the land whose revenue had been alienated at that time has since been resumed and its value now flows into the regular treasury.

V.

In no matter is the study of this village more interesting than in connection with the holdings. When we first find detailed records in 1770, there were only 24 holders of land, including the five *inamdars*. The number at various dates since that time has been as follows :—

	Number of landholders	Average size of holding Acres
1771	24	44
1791	41	25
1797	34	31
1811	54	19
1817	48	22
1829	58	18
1840	60*	17½
1914	156	7

During the Maratha rule the holdings were large and the holders few, and moreover, it almost appears as if the number declined in periods of disturbance and rose in periods of peace and good government. The same results have followed in the long British period, and now we are found with a reduction in the size of holdings which would have been almost inconceivable a hundred years ago. It is evident in fact that in the last sixty or seventy years the character of the holdings has altogether changed, until now the average holding is below what is necessary to maintain a cultivator's

* Previous to 1856 I have counted the *inams* as being in possession of single holders We cannot get certain data about this but it makes the figures before that date and after not quite comparable

family. The number of holdings of various sizes now is as follows :—

Size of holdings					Number of such holdings
More than 40 acres	..	..	..	..	1
30 to 40 "	..	..	..	..	1
20 to 30 "	..	..	..	..	9
10 to 20 "	..	..	..	..	18
5 to 10 "	..	..	..	..	34
1 to 5 "	..	..	..	..	71
Below 1 acre	..	..	..	..	22

The excessive sub-division, which has progressively increased during British rule, is recognized as a very great evil. Mr. Keatinge has suggested that an economic holding of good dry land, such as most of this village consists of, in the Western Deccan and with an Indian ryot's standard of life, would be about ten to fifteen acres. Even, therefore, if each holding were held in one block, it is evident what a large proportion of them (81 per cent.) are below this size. It means, therefore, that by far the larger number of holdings cannot, under the most favourable circumstances, maintain their owners, but that they must rely on other occupations, either at home or away, to support their families, or that they must sub-let their holdings.

The conditions are worse even than this makes out, because the land held is not only small in area but is divided into a large number of fragments. That is to say, that when under Hindu law landed property must be divided among the members of a family, the division is made by partitioning each piece of land, and not by the various claimants taking the whole of various sections of it. The evil result is very apparent in the village now under consideration.

In fact out of 156 landholders in the village only 28 hold all their property in a single survey number and in a single piece. The land is split up into no less than 711 separate plots and the largest proportion of the plots are under one acre in size. The following

table shows the extreme condition to which the sub-division of lands has gone :—

Size of plots	Number of plots of this size
Over 20 acres	1
From 10 to 20 acres	7
From 5 to 10 „	21
From 1 to 5 „	266
From ½ to 1 acre	211
Under ½ acre	212

So far nothing has been done by the public authorities to stop this excessive fragmentation of land which is an evil of far greater moment than that merely resulting from the sub-division of holdings themselves. It has in fact all the evil of very small holdings in that it prevents the use of machinery and labour-saving methods, and, on the other hand, it has all the evils of large holdings in that it hinders the adoption of really intensive cultivation by any holder, which is the great advantage of small holdings. I do not want to discuss here the methods by which public authorities might attempt a way out of what is an obvious difficulty, but the matter has been very seriously tackled in two or three countries of Europe and also in Japan where a similar condition had grown up.

At first sight it would appear as if the people were settling this by natural methods, namely, by the abandonment of village life (though not of village land) by an increasing number of people, and by sub-letting a large proportion of the land. The extent to which the landholders have left the village without giving up ownership is shown by the fact that only 64 per cent. of the registered landholders cultivate their holdings. The remainder have become labourers either in the village or away from it, and though they still hold their land they have ceased being cultivators in the ordinary sense. The land is thus sub-let, and the extent to which this is taking place is evident, for our investigations show only 109 actual cultivators in 1915 as against 156 landholders, or 140 if joint holdings really held by one of the joint-holders are excluded. We have then the introduction of cultivators who are not landholders who form 17 per cent. of the total number of actual cultivators and some of

whom deal with larger areas of land than most of the actual landholders.

I had expected that these new non-landholding cultivators would be chiefly outsiders. This is not, however, the case. Practically all of them are members of the village who had not formerly cultivated land but who had official connection with the village, such as village Mahomedan, the village barber, and so on, together with some members of the leading families who for some reason had no share in the land. It will thus be seen that the average size of the area cultivated by one man is greater than the area owned by one man. If we take 10 acres as being the smaller limit of an economic holding, then we find that while only 17 per cent. of the holdings are above this limit 23 per cent. of the areas cultivated are larger than this. There is hence a tendency for the area of cultivation to be larger than the area owned. In spite of this tendency, however, the bulk of the areas cultivated are still incapable of supporting the families in ordinary village conditions.

If instead of considering the total area cultivated by one man we turn to the extent to which this is cut up into fragments we find an unexpected state of affairs. The number of fragments in a single man's cultivation is even greater than the number of fragments in a single holding. The number of separate plots cultivated separately in the village is not less than 729, and again by far the greater proportion of these are less than one acre in size. All the remarks which I have made regarding the evil effects of the minute sub-division or of the cutting up of holdings into minute fragments are of very much greater force when applied to the cutting up of cultivation into such fragments. In a village such as we are considering, without any material amount of irrigation, it seems to be a disadvantage without any mitigating quality. If the plots are close together the evil is modified, but in other circumstances (and these are by far the most frequent) it means endless loss of labour and time without any compensating advantage.

I am not desirous of discussing here remedies for this state of affairs ; but two results of this excessive fragmentation of holdings should, I think, have attention drawn to them. (1) It prevents

effectually any outsider with capital from entering on cultivation on a large scale in this village. When a man may have to deal with 20 or 30 or even more landowners in order to get a stretch of land of 30 or 40 acres, and any one of those can spoil the continuity or self-contained character of his cultivation, nine men out of ten will refuse to have anything to do with such a scheme. (2) The impossibility of introducing outside cultivators with more enterprise makes the introduction of new and better ideas in agriculture exceedingly difficult. Small holders, when conditions favour the introduction of new ideas, make the most progressive cultivators in the world; when the land is so excessively cut up as in this village, which, I believe, is a typical one in the Western Deccan, the people form a body as hard to move from tradition as any we can conceive of.

VI.

This leaves us to consider the character of the people, their caste, their material condition, their sources of income, and in general, the manner of life which results from the conditions in which they are placed. The village with which we have dealt is a small one, and from a recent house-to-house census which we have made it contains 112 families and a population of 556. By far the larger proportion of these are, of course, Marathas by caste. There are in the village, however, as in practically all other villages, a few families of village servants such as a single Mahomedan butcher, a *chambhar* for making shoes, a barber, four families of *mangs* whose principal duty is to make ropes, and in addition nine families of *mahars*. Housing in the village is astonishingly good, considerably better than in many, if not most, villages I have visited. Each house, in fact, has an average area of about 200 square feet. There are five people per household—a rather large number at first sight. But many of the families are joint and the number of children is exceedingly small. Though there are nearly two men and two women per household, yet the number of children, both boys and girls, is only 164 in the 113 households of which the village consists. This is to me somewhat extraordinary and, if found to be the case

in other villages, would seem to be an exceedingly serious matter. Some years ago I drew attention to the small number of children in certain communities of the depressed classes. The number here, in a village composed almost entirely of Marathas, presents the same condition of things in an even emphasized form.

By far the larger proportion of the people in the village work on the land, but the place is just near enough to Kirkee and to Poona to cause a considerable number to be attracted to work in these places. Of course, recently, at the time when our census was taken, the ammunition factory at Kirkee was working at extreme pressure; but I must own that I was astonished to find no less than 87 men and boys from this village were going there every day to work. Considering that there are only 287 males in the village this means that about thirty per cent. of the male population go five miles every morning to work in the Kirkee factory, and five miles back again in the evening.

Beyond this, eight people from the village carry milk daily into Poona City for sale. Each one conveys from five to six seers and may be considered to obtain about six annas per day for this service. Thus practically the total time of eight people is taken in carrying 100 pounds of milk to Poona City for sale in the city. There are a few others who work at jobs other than cultivation. Some who possess bullocks do carting on the roads. One or two stone quarriers live in the village, and there are besides the village servants of whom I have already spoken. So far hardly any one has gone from this village permanently to work in Bombay. It has its representatives, however, at Bombay, Poona, and at a few other large towns, who take temporary labour there and return to the village when needed. At the time of our inquiry there were six men away in this manner.

Thus what would be purely an agricultural village if the subdivision of land was less complete than it is, has developed into one from which nearly a third of the male population is practically compelled to work outside. One can say with confidence that if the village were further away from a labour centre, a large proportion

of the people would have to go to reside in Bombay or elsewhere for work. The going is not a choice; it seems to be an economic necessity. Here the Kirkee factory takes the place of Bombay, but the principle is the same, and it seems the direct result of the fact that most of the holdings are now too small and too scattered to maintain their owners.

Such going away would probably be only the second effort on the part of the village people to retain a sound economic position. The first would be the borrowing of money either on mortgage of land, or on personal security with a guarantee of selling the crop through the money-lender who advances the money. I have been fortunately able to get what I believe is a fairly accurate statement of the debts of the people of the village. Debts on the security of land are now officially recorded; the remainder is generally so well known that a false statement would soon be detected. The debts are Rs. 5,820 on the security of land under one of the various forms of mortgage and Rs. 7,495 on personal security, or a total of Rs. 13,315 on the village. This is an excessively large amount, and as a result the interest is very high, varying from 12 per cent. to 72 per cent. The average interest charged is 19½ per cent. This means an average indebtedness per family of Rs. 118, and if we take all the debts as a charge on the land, an average charge of nearly Rs. 13 per acre. Considering that the average sale value of land in the village is probably not more than from Rs. 70 to Rs. 90 per acre, this would mean that the whole of the land is involved to the extent of one-sixth of its value at least.

This assumes, of course, that the land is the only capital, and this is very nearly the actual state of affairs. Beyond the land the cattle, numbering 284, represent the chief asset of the people. The value of implements may almost be neglected, and that of houses is very small. I hope later to get more accurate figures, but for the present I think the total sale value of the village and its property cannot be much more than one lakh of rupees. If this is the case its indebtedness is over 13 per cent. of this sale value, and entails an annual charge on the village of Rs. 2,600.

This load of debt seems to me to be the first result of the extreme sub-division of the lands, or, in other words, it is due to the increase of the population tied to the land without the increase in the intensity of the cultivation necessary to support them. When by incurring debt the position became no clearer, then a certain number of the members of most families have gone away for work. In the case of seventeen typical cultivators' households for which we have data on which, I think, we can rely, no less than 33 per cent. of the total income came from such outside sources. I cannot help thinking that this is likely to increase, and that either a complete separation from the land of a considerable proportion of the young male population will occur, or else while retaining an interest in the land as owners, they will in a much larger measure than at present become labourers elsewhere and sub-let the land which they hold. The land in the village has still a rental value of Rs. 7 per acre on the average, or from four to five times the amount of the Government assessment.

The only alternative to this, it would seem, would be a very considerable increase in the intensity of the cultivation by more careful treatment of the crops the people now have, or else by the introduction of more paying crops than they grow at present. We must therefore now consider their crops and methods.

VII.

The cultivation at Pimpla Soudagar is absolutely typical of the dry villages of the Western Deccan. Very little advance in implements and methods seems to have yet been made, though some new crops have been introduced in recent years. As to implements of cultivation a complete set such as is used by the people would cost about Rs. 40, and they are all made locally from beginning to end. The wood is grown in the village, the carpenter is a servant of the village, and except for the very small quantity of iron required for the tip of the plough-share and the blade of various other cutting implements, the village would be quite independent. All repairs to these implements are paid for in *baluta* or a fixed charge on each crop produced, but the carpenters are paid

in cash for new implements made. The use of the modern iron plough is only just beginning, and the hire of these from Poona shows signs of being taken up.

I have already alluded to the very large area of fallow. This is always a sign of backward agricultural methods, of insufficiency of manure, and generally of inadequate cultivation. As a matter of fact the only manure available in Pimpla is that from the cattle, and some of this is at least preserved in a series of primitive manure pits outside the village site. There are no cattle sheds in the village whatever. The animals either remain outside or else are tied in the verandas of houses. No use whatever is made of the cattle urine and two-thirds of the dung is used for making into dung cakes for the Poona market. All the year round, except in the rainy season for three or four months, the process of preparing cakes for burning goes on on the rocky parts of the river bank. The sole manure in the village is therefore at most one-third of the dung alone from under 300 cattle, most of which are away the greater part of the day where the dung cannot be utilized for manure at any rate. I estimate that not more than 400 cartloads or 150 tons of cattle manure, mixed with house refuse, is available each year in the whole village.

It might at once be asked why outside manures are not purchased. The people of this village, and of all others where irrigation facilities do not exist, maintain, and I believe that they are right, that unless you can secure an adequate and certain water-supply, it does not pay to lay out money in buying manures. The water is so uncertain that the risk of wasting this money is too great. The only manures which it has paid to apply, so say the people, are the cattle manure which costs them nothing, and that obtained by allowing shepherds to feed and keep their sheep on the land which it is desired to manure. The crops are grown, therefore, with very little manure at all, for 150 tons of cattle manure per annum and, say, 40 acres on which sheep have been allowed to stay, make a very small quantity. The yields of crops are hence very small. The small yield is probably still further diminished by the fact that rotations seem very little attended to. Only forty acres in the whole

village were under leguminous crops (except peas, of which more later), or four per cent. of the cultivated area, and these are recognized as the crops which keep the soil in good condition.

The cause of this seems to be that the people will not cultivate a crop unless they consider it is fairly certain, and unless it is either needed for the food of their own families and animals, or else brings cash into their hands. The idea of using crops to build up the fertility of the land has not entered the minds of the people at all. And this is the case in spite of the ease with which it could be done. There seems to me a very large field of work in villages similar to Pimpla in showing to the cultivators how, at a minimum of cost, the fertility of the soil can be built up by a green-manuring crop in the rainy season.

The actual cropping of the village is very typical. *Jowar* * occupies by far the greatest area, giving, as it does, both grain and fodder, while *bajri* † either alone or with *tur* (pigeon-pea) takes its place on the lighter land. These crops form the centre of the cropping scheme in most dry villages of this part of the Deccan. The produce of neither of them is usually sold, and they form the staple food of man and beast.

Side by side with them are the money crops—those which are sold and for which cash is received. I do not know why cotton is not grown here, but there is none. Formerly the money crop used to be wheat, rotated with gram, and twenty years ago we were told the village was largely a sheet of wheat in the cold weather. This has now been largely abandoned owing, the people say, to the repeated failure of the late rain in October and November which is essential to the successful cultivation, and to the increasing need of fodder for cattle, of which wheat furnishes very little as compared with *jowar*. There is no doubt that in the last fourteen years the late rains have been very much less certain than they were thirty years ago. Between 1877 and 1890 adequate rain for wheat fell in Poona in October in twelve years out of fourteen, from 1900 to 1914 it fell only eight times out of fourteen. In November in the

* *Sorghum vulgare.* † *Pennisetum typhoideum.*

former period the rain was sufficient in nine cases, in the latter only in three cases. Whether this is a cyclic variation and a period is coming when wheat will be again a suitable crop we do not know, but the change in the last twenty-five years is as clear as any such change can be, and the cultivators are quite right in their contention that the rain has become less suitable for wheat grown without irrigation.

It is curious to find that wheat has been replaced by two crops largely grown together, whose disposal depends purely on the nearness of the Poona market. We were astonished indeed to find that wheat had to a considerable extent been replaced by carrots and peas as a money crop in the village. These crops are now grown extensively, and the crop is stated to need far less rain than wheat required. Carrots give a cash crop in Poona, so do green peas; the tops of the former and the vines of the latter are excellent fodder.

The rest of the land is devoted to less important crops. Niger seed or black *til* is an oilseed which forms the favourite crop of light and shallow land. Gram for some reason which I cannot understand is now a minor crop on the same class of land. Groundnut which has been such a great success elsewhere in Western India, is not welcomed here, and is said not to pay nearly as well as carrots and peas.

Let us consider the returns from these crops, for it must always be recognized that each crop, in the cultivators' minds, must pay its way. We can calculate these in two ways. One is that usual here, when we give the return supposing all labour to be paid for. In the other we suppose the cultivator's labour is his own, and that it should not be calculated in the return. The results with each of the crops, under both methods of calculation, are as follows :—

	Profit per acre paying for labour		Profit per acre with cultivator's own work
	Rs	As	Rs
Jowar	12	6	18
Bajri and *tur*	7	1	13
Carrots and peas	13	0	33
Wheat	12	0	15
Gram	13	10	15
Niger seed	4	0	6
Groundnut	7	12	27

The first column gives the return to a capitalist farmer; the second to a working cultivator. The difference is greatest with those crops which require the greatest labour, and one can easily see why after the food for the household has been produced, a cultivator prefers a crop like carrots and peas to one like wheat, apart altogether from the question of the climatic difficulty in recent years. The latter crop (wheat) would be the natural resource of a capitalist; the former is naturally preferred, and is likely to be more preferred in the future, by working cultivators.

The average net return per acre of land cultivated in the village to a working cultivator is about Rs. 14-8. Ten acres will therefore bring Rs. 145 or about Rs. 12 per month. It will be seen that this is little enough for the maintenance of a family; a less quantity of land will make such maintenance impossible.

VIII.

With this I must stop. I have only been able to sketch in the slightest manner some of the more obvious results of our inquiry. But we have seen how, in a typical dry village in the Deccan, the population has increased, the number of landholders has increased, and the holdings have become so split up into fragments, that not only are the areas now held too small in the vast majority of cases to maintain the family which hold them, but also they now exist in the most awkward form for economic cultivation. We have seen how this was first met by the incurring of debt, which now hangs round the neck of the village to the extent of 13 per cent. of the total value and pays about 20 per cent. on the average in interest. The cultivation of a dry area can never pay for this, and the next step has been the going out of nearly 30 per cent. of the whole male population to non-agricultural work This enabled the balance to be kept for the moment—but the next step seems to have been the modification of the cropping so as to make the village more self-sufficing for food and fodder and the devotion of more area to a crop which at least pays a working cultivator better than that formerly grown. What will be the next ? I can see no hope unless one of three things happens. Either the intensity of cultivation

must be increased, and to do this, the removal of some of the present load of debt and hence more easy financing seems to be needed. In addition better use must be made of the soil resources either by the demonstration of the paying character of green-manuring and other methods, or else new crops must be found which will yield better and more certain returns in the soils of this village. Or finally some change must be made which will prevent, if not the sub-division, the excessive fragmentation of the land, and will remove from an interest in the village land a large number of those who now have it. I should myself regret to see this removal of population and the creation of a large landless proletariat, but I do not wish to impose my views in the present paper. I have tried to present a cold-blooded sketch of actual conditions, and I leave others to thrash out the many problems which our study of this village raises—itself one of many thousand similar communities in the Bombay Deccan.

AGRICULTURAL BANKS.*

BY

HENRY WOLFF.

In our review of the First Part of Vol. I. of the *Indian Journal of Economics* which appeared in the October (1916) issue of this Journal we expressed our emphatic dissent from the opinion expressed by Mr. D. E. Wacha in his article on Agricultural Banks in India. We give in the following extract the views of Mr. Henry W. Wolff on the subject.—[EDITOR.]

IT is only quite recently that my attention has been called to the existence of Mr. D. E. Wacha's article in the first number of the *Indian Journal of Economics*, and only a few days back that I have been able to obtain a look at that article. I frankly confess that I have never experienced greater surprise than in taking note of Mr. Wacha's rather bold assertions. Is it possible? At the very time when Egyptian authorities are casting wistful looks at India, well armed as it is since 1904 with credit banks, the number and results of which have filled the co-operative world in Europe with admiration—and are considering what steps can be taken to acclimatize banks of the same order in their own country, as a substitute for the Agricultural Bank of Egypt, whose occupation as a bank for the small peasantry is practically gone since the passage of the " Five Feddan Statute " of 1913, and which found its borrowers such bad repayers that in 1910 it had 2,544 actions for recovery pending amongst about 40,000 borrowers, Mr. Wacha comes forward to recommend the formation of an imitation " Agricultural Bank of Egypt " for India.

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It was in 1910, when a Bill drafted under my instructions and brought in by Lord Shaftesbury for facilitating the formation of co-operative credit societies in this country was before a Select Committee of the House of Lords, that I questioned Lord Cromer, the founder of the Agricultural Bank of Egypt, who was a member of that Committee, and who evinced unmistakable interest in and sympathy with the object of my Bill, why at the time he had had recourse to a capitalist, State-patronized institution rather than to co-operative banks, in the principle of which he quite evidently believed. I related to him that at the time I had been advised (by the late Lord Ilkeston) that I was about to be consulted with respect to the organization of co-operative banks in Egypt. And accordingly I felt some disappointment at his selection of a different method. Lord Cromer's reply was that he had not at the time considered the fellaheen "ripe" for co-operation. That is an explanation which, however earnestly meant, was bound to sound a little odd to a co-operator and such as could scarcely hold good now, after co-operative banks in India have shown by the test of all tests in credit banking, *viz.*, by repayment made of loans, that they are equal to their task, whereas the Agricultural Bank of Egypt has confessedly failed in that very office.

In addition, I may add, there were thought to be legal difficulties in the way of the formation of co-operative societies attempts to remove which have for some years taxed the legislative ingenuity of the polyglot Council severely. I have seen the draft bills prepared. In the end it was discovered to be doubtful if new legislation was required at all. As a makeshift the Government has, after the partial paralysis fallen upon the fellaheen business of the Agricultural Bank, as a very minute compensation for the loss sustained, authorized the formation of "syndicates" and "groups of borrowers," to which the Agricultural Bank is now empowered to lend. There has not yet been much business. Evidently this is meant as a stepping-stone to more perfect co-operation (on the consideration of which official minds continue busy), in the place of the exploded methods praised up a good many years too late by Mr. Wacha.

The Agricultural Bank has never done anything like the business that the Indian co-operative banks do. Its increase of share capital, which has excited Mr. Wacha's admiration, is no proof whatever of good banking for the purpose here kept in view. That share capital comes from the shareholders, who receive their dividends in virtue of other business that their Bank carries on successfully. There is nothing to be said against the management of the Bank. The fault which has led to the stoppage of one part of its business—the part here under consideration—is the mistaken selection of means whereby to supply the fellaheen.

Speaking of the Agricultural Bank and its working, M. Pierre Arminjon, a professor at the Egyptian *Ecole de Droit*, who is now an old resident in Egypt and a specific student of its institutions, in his excellent *La Situation Economique et Financiere de l' Egypte*, published in 1911, after reviewing briefly but with evident appreciation the results obtained by the Indian co-operative banks, writes thus (pp. 644 ss.) :—" Are not these quotations eloquent and do they not make one sigh for the day when each district and even each village of any importance among ourselves will possess a similar society for the benefit of the fellaheen ? . . . . Meanwhile credit is dispensed to the small peasantry by the ' Agricultural Bank'. . . . The idea suggesting its foundation was of the happiest . . . the peasantry have largely drawn upon its resources—now grown to over £E8,000,000. To what uses has this enormous capital been put by them ? Only too often to one that was quite unproductive, to pay the expense of some merrymaking, to buy some young fellow off his military service. Even when the loan has not been squandered in this fashion, it has often enough been wasted upon the purchase of land that did not pay the interest and sinking fund of the loan. During the last two years the Bank has been able to recover its loans only partially and with great difficulty." And he goes on to quote from the last Report of the Board of Directors then out :—" It is to be feared that in only too many cases the inability of the borrowers to meet their engagements arises from an unproductive employment of their loan." Professor Arminjon points out that repayment is not to be obtained, because the loan was badly employed,

the lenders not being able to ascertain, and much less to control, the employment. "Well," says he, "that is precisely what the managing committee of a co-operative society *can* do, its members being bound in common liability and knowing, and being able to watch, one another."

Allow me to quote briefly from some of the Annual Reports of the Agricultural Bank of Egypt. In the Report for the year 1913 the Directors, after explaining the purport of the new law which deprives owners of properties of 5 feddans (about 5 acres) or less of the power to pledge their properties, say:—"This is a complete reversal of the policy of the Egyptian Government that led to the formation of the Bank, which was founded with the object of lending to the small cultivators on the security of their land." Under the new law "no such mortgage credit is to be allowed . . . . It will be necessary to create a new system of agricultural credit." Of the 235,000 clients now on the books of the Bank the large majority are holders of 5 feddans or less. The law thus "reduces the business of the Bank by about two-thirds." The Report of this year accordingly shows a great decline in lending business of the kind referred to, the number of agricultural loans having dwindled from 23,070 for £E1,239,615, at which it stood in the preceding year, to only 351 for £E72,351. Recovery has all along, except quite in the beginning, been a difficult business for the reasons stated. In 1910 arrears figured at 18·9 per cent. of the amounts due; in Upper Egypt alone even to 53·8 per cent. In 1914-15 arrears even reached the appalling figure of 74·4 per cent. from which a reduced business (£E100,304 as compared with £E1,212,087) brought it down to 25·8 per cent. in the following year. Well, 25·8 per cent. is assuredly quite enough. In 1916-17 the amounts due for repayment, having stood at £E1,886,046 in 1908, had shrunk to £E816,691.

Mr. Wacha gibes at the modifications which have under practical testing proved desirable in the Act of 1904 and have been effected by the later Act of 1912. Is the Agricultural Bank of Egypt a good case to quote against this? We have heard that by the law of 1913 its whole purpose has been reversed. On the other

hand there is absolutely nothing unusual or objectionable in the amendment of the Indian law of 1904. In that year the Viceroy and Council legislated on untried ground. As a matter of course the Act would require to be completed after testing by experience.

I do not suppose that there is any one who has seen more of co-operative banks of various kinds and in various countries than myself. And I can candidly say that the progress of the co-operative banking movement in India has surprised me by its rapidity and its general soundness and filled me with satisfaction. It does very great credit to those who have been charged with the administration of the Act. On new ground, to which the old, well-tried principle had somehow to be adapted, they have shown admirable resource and judgment. And I judge the movement to be safe in their keeping. Certainly it is not likely to produce anything like the cataclysm of defaults in repayment which has marked the dealings of the Agricultural Bank of Egypt, the methods of which, so I would point out in conclusion, are not really applicable to India, as an inquiry instituted some years ago has made clear. The two systems of administration are too essentially different. There is, among other things, no "omdeh" in India, who forms such an essential feature in Egyptian credit business for small cultivators. Indians will do well to rest content with what they have and not throw away their tried gold for Brummagem brass.

THE REFORM CLUB,
London;
September 13, 1916.

HISTORY OF RICE.*

It is interesting to note that Europe is indebted for its first acquaintance with rice to the Arabs who carried the plant into Spain in the seventh century of our era under the name aruz which became arros in Spanish, rizo in Italian, and from which is derived our name rice. Rice was first cultivated in Italy near Pisa in 1468. It was not introduced into America until 1700 and then, it was said, by accident into Carolina, and at one time the Southern States of America furnished the largest proportion of rice imported into England. There are said to be far more varieties of rice than of any other of the farinaceous grains used for food in Europe, and the Burmans, we believe, enumerate several hundred kinds. But a considerable number of the names given for varieties are founded on distinctions which are unappreciable by Europeans, such as variations of times of sowing and ripening, of soils and modes of culture. Such minute differences may perhaps point to antiquity in the culture of rice, which though not mentioned in the Bible is in the Jewish Talmud. There is no evidence of the existence of rice in Egyptian remains, nor is there any trace of it as a native plant among the Greeks, Romans, or ancient Persians, but there is proof of its cultivation in the Euphrates valley, in Syria, and in Mesopotamia, several hundred years before the Christian era. Crawford on philological grounds considers that rice was introduced first into Persia from Southern India. Other writers think that rice was first grown in China where a ceremonial ordinance was established by the Emperor Chinnung, 2800 years B.C., in accordance with which the Chinese Emperor for many centuries participated himself yearly in the sowing, whilst the seeds of four

* Reprinted from the *Rangoon Gazette*, dated 5th March, 1917.

different kinds were at the same time sown by four princes of the Imperial House. This Chinese ceremony, at any rate, shows that over 4,700 years ago it was already the food of many millions of the most civilized race then existing in the world. During the Irish potato famine in the last century rice was substituted for potatoes in some of the workhouses and was reported some months afterwards to have produced cases of scurvy in some of the inmates. But that may be greatly owing to the effect of a sudden change to an unaccustomed diet and partly no doubt to the deficiency of mineral matters characteristic of this grain. It suggests, no doubt, the utility and wholesomeness of a mixed food. No other grain is more easily digested, but it is not by itself a complete and perfect food, requiring the addition of some more nitrogenous material such as is found in meat, lentils, milk, or eggs. Starch, a necessary of life, enters more largely into the composition of rice than it does in wheat, oatmeal, Indian corn, potatoes, or bananas.

SOURCES OF CONTAMINATION OF THE MILK SUPPLY.*

BY

N. S. GIBSON.

WHEN speaking of contamination of milk, we refer to the mixing of undesirable germ-life with the milk and the way in which it gets there. The first place in which milk can be contaminated with those germs harmful to human life or undesirable from a dairyman's point of view, is within the milk-producing organs of the cow, *i.e.*, the mammary glands, udder, etc. Any disease from which the animal is suffering, that is capable of being spread by germs, is carried by the blood stream into the mammary system and there passes into the milk ; such diseases as tuberculosis, etc., are spread in this manner through the medium of milk from the animal to human beings. Animals should be supplied with perfectly pure water, because, should the water be impregnated with disease-germs, as it may be, and should the cow upon drinking the water pass the germs into her system, although she may not suffer herself from the presence of the germs, she may pass them on to human beings through the medium of the milk, to whom they may be harmful.

Any animal suffering from disease should at once be separated from the milking herd, and should she continue in milk, this should on no account be used.

Next, dirty cows may cause milk to become contaminated. In exercise yards, fields, jungles, and pools of stagnant water animals come into contact with air, water, and filth-born germs. These germs cling to the hair on the animal's body, and unless the animal

* Reprinted from the *Journal of Dairying and Dairy Farming in India*, July 1916.

has a thorough grooming some time before milking, the germs find their way into the milk during the milking process.

The next point to be considered is the cleanliness of the milker. He should be healthy and should not on any account be allowed to milk if suffering from any disease; otherwise he may easily pass germs into the milk by contact. Milkers should be perfectly clean in every way: clean clothing should be kept and put on for the time of milking, and not used for any other purpose; milkers' hands must be very clean and should be washed after milking each cow; fingernails must be kept short, as long nails provide a harbour for microbes.

It is most important that the milkers should wash their hands after milking each animal with the view of preventing the spread of disease from one animal to another through the agency of the milkers' hands.

Milking vessels, cans, and other receptacles in which milk is transported should be carefully cleaned at once after use, warm water being first of all used, afterwards scalding may be carried out to kill germs. Milking pails, etc., may be placed in the sunlight, as this is the best of all germ-destroyers. The least number of times milk is handled between the cow and the consumer, the least number of germs will it collect.

Cattle-sheds are frequently hotbeds for the breeding of bacteria; corners where dirt and dust may collect, where sunshine may not penetrate or fresh air circulate, form an ideal place for the rapidly multiplying germ

This gives us ample reason for daily washing and cleaning and frequent whitewashing of walls and roof so that with clean cows, clean milkers and surroundings and milking vessels, we may expect to turn out from our cattle-yard that great factor in human life—clean milk.

Leaving the place where the milk is produced, we next go to the dairy. This should be, and generally is, a place where the rules of clean handling of milk are observed.

On receiving milk from the cattle-yard, the first process to be carried out is careful filtering or straining. The milk is passed

through a strainer, fitted with a layer of cotton-wool between two removable gauzes. The cotton-wool discs are cheap and should only be used for a small quantity of milk, being replaced by a new one as soon as it collects a fair amount of dirt.

This filtering process removes practically all the dirt and it is almost past belief to see the quantity of dirt that collects in milk carelessly handled in the cattle-yard.

In such a hot climate as that of India, milk must be pasteurized and cooled if it is intended for transport or for anything but immediate consumption. In any case cooling should be carried out to as low a temperature as possible to ensure its keeping qualities for a longer time than milk not so treated.

With the use of the pasteurizing machine, however, we have the advantage of killing disease and other germs that feed on the constituents of milk, and driving other germs into the spore condition; then in conjunction with pasteurization, the use of cold water and brine coolers and finally a cold store brings the temperature down and keeps it below the minimum standard necessary to germ-life.

In the dairy as in the cattle-yard, workers should be healthy and clean, all vessels clean and free from congealed albumen, etc., which may collect in the gauzes of strainers, ridges of pails and milk vessels, especially if very hot water is used in the first washing of utensils, the heat causing the albumen in the milk to coagulate and form a hard cake in the ridges, joints, etc., of vessels which is very difficult to remove. Likewise, the floors and surroundings should be kept exceedingly clean for the reason that, wherever dirt is, the microbe is there also.

Flies must be prevented from coming into contact with the milk, and must be excluded from the dairy by wire gauze doors and windows, and if they do enter must be killed by means of fly traps, flappers, or any other means. Milk must be transported to customers by road or rail in closed vessels and in clean surroundings. An instance came under the writer's observation a short while ago, where churns of milk were packed in a goods-van, in which dogs, chickens, etc., also travelled.

Milk should receive careful treatment at the hands of the purchaser when delivered by the dairy delivery man, otherwise all the care that has been used in the endeavour to produce a pure product will be thrown away and count as though it had never been. Clean jugs and vessels should be used, and if all the milk is not used immediately, the vessel containing the milk should be placed in a basin of cold water and covered with a piece of muslin. Even better is the use of a small ice-box.

In the production and handling of milk, cleanliness is the rule that everyone should obey and enforce with utmost rigour and is the only way in which we can combat the spread of contagious diseases by means of the milk supply.

THE POSSIBILITY OF UTILIZING *REH* OR *SAJJI MITTI* FOR THE MANUFACTURE OF COMMERCIAL ALKALIS.*

WE are indebted to the Hon'ble Mr. A. H. Silver, Director of Industries, United Provinces, for the following Note :—

There has recently been great shortage of supplies of alkalis. Sodium carbonate (soda ash) and caustic soda are both largely used in this country in many industries. The manufacture of glass and soaps, both of which are carried on fairly extensively in this Province, are almost entirely dependent on the availability of alkalis which have been hitherto obtained mainly from England. Owing, however, to the needs of the war and the difficulties of transport, India has not lately been able to get more than a small part of her requirements. Two recent shipments have been lost at sea thus emphasizing the shortage due to the causes mentioned above.

This Department has been alive to the needs of this Province and has done its best to secure supplies as far as possible.

A note on the possibility of making caustic soda from imported soda ash was published last year. At that time there was scarcity of caustic soda but soda ash was freely obtainable. This note led to numerous enquiries, and it is believed that thereby many parties using caustic soda were enabled to make their own caustic. Since then soda ash too has become very scarce. This Department has arranged to secure to this Province a fair proportion of any supplies of these chemicals which reach this country. Efforts are also being made to get supplies from the Magadi Soda Company of British East Africa, as also from manufacturers in Japan and America.

The laboratory attached to this Department has given attention to the possibility of reviving the extraction of alkalis from the

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* Reprinted from the *Indian Trade Journal*, dated January 26, 1917.

efflorescent deposits on *usar* lands. Before the advent of English alkalis, these deposits were largely made use of for the manufacture of crude sodium carbonate, sodium sulphate, and caustic soda which not only met all local requirements but were also available in sufficient quantities for export to Calcutta and other parts of India.

Generally speaking, the efflorescent deposits of *usar* lands, indiscriminately known as *reh* or *sajji mitti*, are variable and uncertain mixtures of sodium carbonate, sodium sulphate, and sodium chloride. Dr. Hill found some years ago that in many deposits there is sodium bicarbonate present along with the normal carbonate. Much has been written on the subject of these deposits by many investigators. A *Reh* Committee was appointed in 1878 with Mr. Stewart Reid as President and the late Sir Edward Buck as Secretary. Attention by all workers was given mostly to the question of the reclamation of *usar* lands and the prevention or eradication of deposits of *reh*. The utilization of the salts contained in *reh* was considered a matter of secondary importance and no organized research seems to have been undertaken with a view to devising methods for the production of commercially pure salts from the native deposits. The methods used locally, before imported alkalis captured the Indian market, were very crude. The efflorescent deposits were scraped off the ground by *lunias*, and the salts were dissolved out in water which was freed from humus and other suspended and insoluble matter by a process of filtration through earth. The clear liquid was allowed to evaporate and the soluble salts were recovered.

This was all done by the *lunia* who collected the earth on payment of a royalty to the owner of the land.

At all events during the war, it should be a practicable and paying proposition to make commercially pure sodium salts from *sajji mitti* or *reh*. Samples of deposits obtained from various parts of the Province have been from time to time analysed in the laboratory attached to this Department. Broadly speaking, the deposits may be divided into two main classes, *viz.* (i) those which contain large amounts of sodium carbonate and only a small amount

of sodium sulphate, (ii) those in which large amounts of sodium sulphate are present and the proportion of sodium carbonate is very small.

There is so much variation in the composition of both these classes of deposits that it would serve no useful purpose to give analytical results obtained with random samples. To form, however, a rough idea, the soluble salts contained in these deposits may be taken as occurring in the following proportions :—

	Class I Per cent	Class II Per cent
Sodium Carbonate .	70—90	1—10
Sodium Sulphate .	1—10	60—85
Sodium Chloride	5—20	5—20

Besides these there are present in small quantities salts of alumina and phosphoric acid.

Some experiments carried out in this laboratory hold out hopes of the possibility of making fairly pure sodium carbonate from deposits of both these classes.

In the case of Class I advantage was taken of the difference of solubilities of sodium carbonate and sodium chloride. The latter is nearly twice as soluble as the former at the ordinary temperature. By careful fractional crystallization it is possible to eliminate practically all the sodium chloride.

To the glass-maker, the presence of sodium chloride in the alkali he uses is very detrimental. The presence of sodium sulphate is immaterial. As a matter of fact sodium sulphate has now largely superseded sodium carbonate in glass-making. The former compound is said to give better results and is to-day used largely in England in preference to sodium carbonate. The sodium carbonate obtained from these deposits can be easily causticized by means of lime. Instructions for carrying out this process will be found in the note published by this Department on the manufacture of caustic soda from soda ash. In the process of causticization most of the sodium sulphate present in the crude carbonate is precipitated out as calcium sulphate, so that the caustic soda produced is fairly pure.

Deposits belonging to Class II are a little more difficult to deal with. If it is intended to prepare sodium sulphate, advantage may be taken of the difference of solubilities of sodium sulphate and sodium chloride, the latter being nearly twice as soluble as the former. The process would be similar to that just described under deposits belonging to Class I. Sodium sulphate has great many uses. Reference has already been made to its use in glass-manufacture. It is required in large quantities for preserving hides intended for export, and it finds a fairly extensive application in dyeing.

Pure sodium carbonate has been made successfully in this laboratory from crude sodium sulphate extracted from deposits of Class II. The method used was similar to that employed in the Leblanc process of manufacturing soda ash. The sodium sulphate, which resembles salt-cake, is heated with lime and charcoal whereby a product similar to black ash is obtained. This is lixiviated, and sodium carbonate is recovered by evaporation of the liquors. It is proposed to try these experiments on a fairly large scale and if possible a small experimental factory will be started for the purpose.

More detailed information will be supplied to *bonâ fide* enquirers who have reasonable quantities of *reh* or *sajji mitti* at their disposal if their enquiries are accompanied by samples of crude *reh* or *sajji mitti.*

GERMANY'S EFFORT TO OBTAIN NITROGENOUS COMPOUNDS.*

ALTHOUGH elementary nitrogen is not only useless, but positively antagonistic, to the life of plants and animals (except to that of some bacteria which take free nitrogen from the atmosphere and convey it to the roots of leguminous plants), combined nitrogen is absolutely necessary for their metabolism. Animals obtain nitrogen from the vegetables they consume, plants from the nitrogenous constituents of the soil. The soil obtains part of its combined nitrogen from decaying vegetable matter and from the waste products of animals ; the remainder has to be added. The two chief forms in which it is added are sodium nitrate and ammonium sulphate which, to a large extent, are interchangeable. But for the manufacture of explosives sodium nitrate is absolutely necessary and ammonium sulphate useless. Germany, foreseeing that its supply of Chilean nitrate would be cut off by the blockade of the British Fleet, was faced with irremediable disaster unless it could lay in a sufficient stock before declaring war, or devise methods of synthesizing nitric acid. The manner in which this difficulty has been overcome is described by Prof. Camille Matignon in the *Revue generale des Sciences* (January 15th and 30th). Before the war Germany was the greatest consumer of combined nitrogen. In 1913 the consumption amounted to 750,000 tons of Chilean nitrate, 35,000 tons of Norwegian nitrate, 46,000 tons of ammonium sulphate, and 30,000 tons of cyanamide. In 1913 great efforts were devoted in Germany to the preparation of materials necessary for war, and no attempt was made to conceal them. The German Ammonium Sulphate Syndicate had a reserve of 43,000 tons, and on the declaration of war there was probably a stock of 100,000 tons of Chilean

* Reprinted from *Nature*, dated 8th March, 1917

nitrate. Immediately after the battle of the Marne, when a long war was evidently certain, the production of artificial nitrates and of ammonium sulphate was stimulated, the Badische Aniline Company and Bayer & Co. being subsidized to the extent of 30,000,000 marks for the installation of factories to convert ammonia into nitric acid. In peace time 550,000 tons of ammonium sulphate were produced annually in Germany, but this output was reduced once war was declared. As this substance is a by-product in the manufacture of gas and cast-iron, people in Germany were instigated to use gas and coke instead of coal, and by such means an annual out put of 250,000 tons of ammonium sulphate was attained. The problem of converting the ammonium into nitric acid was solved by the Frank and Caro and the Kayser processes. A French chemist, Kuhlmann, had discovered that ammonia is oxidized to nitrogen peroxide when mixed with air and passed over warm, finely divided platinum. The reaction was employed on a commercial scale by Ostwald and improved both by Kayser and by Frank and Caro. By the end of 1915 the Anhaltische Maschinenbau Society of Berlin had established thirty installations for the conversion by Frank and Caro's process, and these had a capacity of more than 100,000 tons of nitric acid per month. But this was only one of the methods adopted. Given a cheap source of electrical energy, it was known to be commercially practicable to prepare nitric acid by the direct oxidation of nitrogen in the electric flame, and this process had been established in Norway by Birkeland and Eyde, who used the waterfalls as a source of energy. The Germans have established a factory employing Pauling's process (a modification of that of Birkeland and Eyde) at Muhlenstein, in Saxony, in the neighbourhood of the Lignite beds, which form the source of energy, and this has an annual output of 6,000 tons of nitric acid.

The third principal method adopted for the preparation of combined nitrogen was the direct synthesis of ammonia. Bosch and Mittasch, two chemical engineers of the Badische Company, had adapted Haber's synthesis to industrial conditions and the company had established a factory with an annual output of 30,000 tons of synthetic ammonium sulphate. In April 1914, the

company increased its capital in order to raise the output to 130,000 tons, and after the battle of the Marne it was subsidized by the German Government to increase the production to 300,000 tons.

Before the war the production of cyanamide in Germany was comparatively small, but it has increased largely under Government stimulus. The cyanamide manufacturers desired a monopoly, but this was opposed by the Badische and other companies and by the gas manufacturers, and the project seems to have been abandoned.

In the direction of the manufacture of manures, it was necessary to economize sulphuric acid, so ammonia was neutralized with nitre cake, and the resulting mixture of sodium and ammonium sulphates was mixed with superphosphate. Moreover, it was found that superphosphate will absorb gaseous ammonia, and although the calcium acid phosphate is thereby converted into the insoluble tricalcic phosphate, it is formed in an easily assimilable condition, and the product is found by experience to act both as a nitrogen and phosphorus manure.

Prof. Matignon seems to be correct in claiming that chemistry has saved Germany from disaster.—(E. H.)

RECENT TENDENCIES IN CO-OPERATION*

BY

J. C. COYAJEE, M.A.

I.

TYPES OF LIABILITY.

IN the earliest years of the infancy of co-operation (until the year 1889) unlimited liability remained the only recognized type. Later still, we can distinguish three forms of liability in occupation of the field of co-operation. There was the principle of combining share capital with limited or unlimited liability, and there was also the system of unlimited liability—a system which can be better expressed as that of "joint and several unlimited liability." In the case of the limited liability societies the members were thus under a double obligation measured by the share they held and the fixed sum which they might be called upon to pay—such were the older forms of liability. In recent years we see the advent of a fourth form of liability—that of the "contributory unlimited liability" (Unbeschrankte Nachschusspflicht). This form is rapidly extending itself and will in all likelihood take up most of the area now occupied by the principle of joint and several unlimited liability. The former is quite as safe as the latter and possesses additional advantages peculiai to itself.

The rule of unlimited liability started with the advantage of possessing a drastic rigour which appealed strongly to popular imagination. Indeed there seemed a danger that an undue importance may be attached to the rule. It was not till 1896 that even a Schulze Congress could venture to proncunce that its members might safely use the path of limited liability. The highest

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authorities, however, never hesitated in correctly estimating the benefits of the limited liability type. Thus Mr. Wolff asserted that "unlimited liability"—retained in a steadily declining degree in Germany—avowedly as a German tradition—was not by any means indispensable to them (banks for medium and large farmers). Schulze argued that the nature of the liability adopted was not a matter of principle but of expediency. The present leader of the Schulze Delitzsch Federation agrees with his great predecessor, but admits that in the early years of co-operation unlimited liability is to be preferred as securing the confidence of depositors and lenders. Cahill has noticed that in Germany unlimited liability alone held the field till 1895; that there was a considerable secession to the limited liability rule till 1900; but that since that year a sort of equilibrium position has been reached. The result was that in 1912, of the Schulze societies, about 40 per cent. adhered to the principle of unlimited liability. It is noteworthy that the Committee on the Establishment of Co-operative Credit Societies in India agreed with the views of Wolff and Nicholson when it laid down that "limited liability might under some circumstances prove more attractive than unlimited liability, but we recognize that in the historical development of credit the latter comes first."

It can be easily shown that limited liability might be so adjusted as to afford any possible extent of safety to the depositor or lender. The value of the share does not by any means circumscribe the obligation of the member, for the liability might be made a multiple of the value of the share. "In Saxony, the share is 5*s*. with a liability of £10, and in Pomerania, 6*s*. with a £12-10*s*. liability." As Cahill says (p. 82) "the nominal value of a share being fixed at 10*s*. with a liability of £5, a member holding ten shares undertakes over and above liability for £5 in respect of the total value of the ten shares a further liability to the extent of £50." On the same subject Haas expressed himself thus :—The form of limited liability existing in Prussian Saxony and Pomerania, however, approaches, for practical purposes, very closely to unlimited liability. The amount of shares and liability guarantee to be taken is not left to the free will of the members but is compulsorily apportioned to the

means of the individual members. "Indeed, in the case of some central banks the liability is a thirty times or even a hundred times the value of the share," and as Cahill remarks, is tantamount to unlimited liability.

As the authorities tell us the choice between unlimited and limited liability is not a matter of principle but of expediency. The adoption of any particular form is explained more by the economic situation developed in any particular district. Thus Herr von Knebel Doberitz observes that "in Western Germany where property is very widely and equally diffused, and where a widely developed co-operative movement existed before the law permitted any form other than unlimited liability, the system of unlimited liability was adopted. The distribution of property in Pomerania is quite different. Here we have large landowners, middling landowners, small landowners, clergymen, schoolmasters, officials, artizans, labourers—extremely diverse magnitudes—to be brought into the same credit society. Here, therefore, the conditions precedent for unlimited liability do not exist." Such was the reason assigned for the introduction of the principle of limited liability.

It must be admitted that the system of joint and several unlimited liability might conceivably cause hardship. *Primâ facie* it is safer for the rich than for the poor because a loss which would be easily borne by a rich estate might easily wipe out a small one. Of course this danger from unlimited liability is in the main of a theoretical nature and has practically not led to any great hardship. The reason for this is to be found in the fact that the organization of the Raiffeisen societies is so developed as to reduce the chances of a loss to a minimum. In the case of a loan the credit of the beneficiary, the purposes to which he devotes it, the nature of the risk run, the process of spending it are all strictly supervised; while the profits from there loans are kept in hand to meet the chances of a possible loss. Nevertheless it is conceivable that unlimited joint and several liability might work hardship to individuals, both debtors and creditors. It might happen that although the particular form of liability was intended to serve the purposes of the creditor, it might fail him in his necessity. Unlimited liability

of the ordinary sort holds within it all the elements of a chaotic liquidation of debt. The creditor might have to bring successive suits against the poorer members, and yet the expense and trouble might bring him scanty recompense. The lucky creditor who brings his suit against the richer members can alone profit by this procedure. On the side of the debtors, too, there is a possibility of needless trouble. Some of the poorer debtors or those who are sued first might lose their all; while those who have had the luck of being sued later might lose little.

The only way to avoid these troubles is to eliminate all direct relations between creditors and members, the latter are to be liable to the society and the society is to be liable to the creditors. Dr. Otto Neudorfer thus defines the new procedure in case of liquidation. By the Austrian Law of 1911, "direct action on the part of creditors, even against the members of an unlimited liability society, is suppressed and these members are placed on the same level as those of limited liability societies. Creditors must not be re-imbursed to the amount of the debts due to them except when the debt is distributed among all the members. However, there is no limit to the obligation of members providing by supplementary payments for the liquidation of debts contracted by the society. They contribute in this way until the creditors are satisfied or until the means of the members are exhausted." This procedure presents a remarkable contrast to the possible scramble under the principle of unlimited liability. All creditors receive equal satisfaction under the new rule, while under the old system a premium was placed on rapacity and ruthlessness. Justice is also secured among the debtors *inter se*, none of whom are bled white unless in the case of absolute necessity; for there is a systematic and just liquidation of the debt *pro rata*.

The system of unlimited liability has proved far from popular in many countries, and its adoption would have militated against the growth of co-operation in those lands. Even in those few countries which have gone in for unlimited liability, it appears nowhere except among the basic units. America has opposed a sort of passive resistance to the introduction of unlimited liability.

As Mr. Morman states, " Practically all of the co-operative societies in Canada are established on the basis of the limited liability of the members." Another authority, M. de Jardins, explains this state of things by alleging that " the people of the Province would never accept the unlimited principle whatever safeguards might be provided, their education being quite opposed to such a system." As to the United States of America, authorities like Mr. Herrick and Prof. Kemmerer agree that owing to the difference of American conditions no hard-and-fast rule is possible in favour of unlimited liability. It has also been laid down that " the average American farmer will not accept the principle of unlimited liability." It is also worth noticing that the Jewish co-operative societies started in the States have fought shy of unlimited liability. With regard to Scotland, the recent American Commission found that " unlimited liability is an unpopular arrangement and better success may perhaps be looked for in the case of banks whose members undertake definitely restricted liability." In Ireland the Departmental Committee on Agricultural Credit argued in favour of " the desirability of leaving open the selection of limited or unlimited liability as a basis for credit societies." As to the state of opinion in England the American Commission was thus informed on excellent authority :—" Experience shows that in England there is great hesitation to take part in a scheme which entails no limit to the liability of individual members. The fact that the liability under the Raiffeisen system is really only nominally unlimited is a point which is not readily appreciated in a country where liability limited by share capital is practically unlimited in commercial undertakings " Russia also is not ready to admit the principle of unlimited liability with any zeal. The majority of the societies in that country are not formed on the Raiffeisen type but are developed on the lines of what Prof. Borodaevsky has styled " the Russian system," and " in the co-operative societies of the Russian system the member's liability is almost always limited."

Sweden like other countries started with a joint and several liability of all members, but this stern rule has been encroached upon in many ways. By the law of 1911 things have been so

arranged that there are no economic associations of unlimited liability now existing in Sweden. Moreover, no member can be called upon to pay until the funds of the association have been proved to be insufficient, and even then the liability of the members is limited to a fixed amount or to the amount of the deposits.

We may now proceed to see in what countries the principle of unlimited contributory liability is making progress. In Germany the Imperial Co-operative Societies' Act of 1889 as amended in 1896 has got provisions regulating societies with such liability. There is to be a declaration of adherence expressly stating that individual members are liable with all their property to pay to the society the necessary supplementary payments for the satisfaction of the creditors. The receiver must without delay draw up an account of the contributions due by retired members and in this account the individual names must be cited with the contribution to fall upon each. It is true that in Germany the principle in question has not made such great progress as might have been anticipated. But that is due partly to the " momentum of the start " and partly to the respect in which the preaching of the first apostle of co-operation is held in his native land. Austria had long felt the need of a new type of liability to correspond to the advanced stage of co-operation reached there, and by the law of 1911 there comes in " the substitution for unlimited liability of unlimited obligation to pay supplementary calls." The economists of Austria welcomed the change. Another country of which unlimited contributory liability has taken a firm hold is Holland. There, even in the case of the Raiffeisen Central Bank the liability once unlimited is modified into something like the unlimited contributory liability.

As regards India a most valuable dictum has been pronounced on our subject by the Maclagan Committee. After observing that hitherto India has loyally adhered to the system of unlimited liability, and that so far that system has not caused any difficulties, the Committee goes on to observe :—" Should it hereafter be found necessary to define it more clearly, we should suggest that it should take the form of contributory unlimited liability, that is to say, that where there is a deficit in the engagement of a society to its creditors

this deficit should, after the full payment of shares (if any), be recoverable by a series of *per capita* levies upon the members up to the full extent of their property, direct proceedings by a creditor against individual members being forbidden." It need hardly be added that this is a most valuable pronouncement in favour of the form of contributory unlimited liability.

The conclusion seems to be that it is not advisable for legislation to show undue preference for any particular form of liability; all forms should be permitted by law so that different parts of the country might adopt the particular form most suited to them. At the same time there is little doubt that in many countries unlimited liability has done yeoman's service in the incipient stage of co-operation. When it has to be departed from, the Union or Central Societies should be consulted as to the departure. There is also little doubt that ultimately societies with unlimited contributory liability will be found to be in possession of a very large portion of the co-operative area.

Notes.

AMERICAN COTTON IN THE PUNJAB.

THE area estimated for 1916, *viz.*, 120,000 acres, was slightly exceeded. Of this area over 30,000 acres were from seed of 4F cotton sold by the Department. The whole crop was of the *Narma** or rough-leaved type found suitable for the Punjab. Prices were remarkably good, as much as Rs. 17/1 per maund of *kapas* being obtained for some lots in November 1916, when the price of Punjab *desi* was only Rs. 8 to Rs. 9. Eleven auction sales were held by the Department and 48,150 maunds of *kapas* sold. The ordinary premium apart from sales was at Rs. 4 per maund. Taking an average crop of 6 maunds, it will be seen that with equal yields the extra profit reaches $120{,}000 \times 6 \times 4 = 28{,}80{,}000$ or over 28 lakhs of rupees.

In the present season at the time of writing this (May 6th) sowings are nearly over. In ordinary years, these would have been finished by April 25th, but owing to a serious shortage of canal water, sowings have been very late and the Department has recommended sowing up to April 28th; and growers having been informed of successes obtained in past years with sowings up to May 15th, a considerable amount of late sowings has been done. Had the season been normal the area under American would have been greater: nevertheless the estimate this year is well over 200,000 acres of which over 120,000 acres are from seed supplied direct by the Department at 50 per cent. premium over bazaar seed. [W. ROBERTS.]

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* *Narma* = Soft.

PROGRESS OF PROVINCIAL CIVIL VETERINARY DEPARTMENTS.

THE statistics compiled by the Government of India from the reports of Provincial Civil Veterinary Departments for the year 1915-16 show what progress has been made by the departments during the last decade. The total cost of the working of the departments in 1904-05 was Rs. 10,82,353 ; last year it amounted to more than 31 lakhs of rupees (Rs. 31,72,625). During the decade there has been a steady rise in the number of veterinary dispensaries, as will be seen from the following figures :—

1904-05	269
1908-09	380
1915-16	456

The number of animals treated at the dispensaries rose in the same period from 256,014 to 863,218. Though the increase in the number of veterinary assistants employed on tour was only a little more than 100 per cent. (318 to 666), the number of animals treated showed an increase of almost 200 per cent. (258,718 to 687,211). The number of bovines inoculated shows an enormous rise from 75,269 to 533,429. Of the latter as many as 395,318 were treated for rinderpest. The number of horse and donkey stallions kept by local bodies advanced from 196 to 304. Of the 342 cattle fairs and shows held last year 176 were held in Assam alone. Twenty-five fairs were held in non-selected districts.

One hundred and nine students passed the Final Examination of Veterinary Colleges ; of these 50 passed out from the Punjab College. Of the 237 newly admitted students 145 were scholarship-holders; it is a pity a larger number of outsiders do not take advantage of these excellent institutions which are maintained by Government at an annual cost of nearly four-and-a-half lakhs of rupees.—[J. MACKENNA.]

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IRRIGATION OF PLANTAINS.

THE usual method of watering plantains is to flood the surface of the plot once a week or oftener if water is available. After every other irrigation the ground between the rows is cultivated by the

bakhar. This method is not only wasteful in the amount of water used but entails considerable expense in cultivation. There is also the danger of damaging the trees at the time of *bakharing*. Lastly, there is no provision for removing water in the monsoon. For more than a year—that is to say right through last hot weather—a very economical method of applying water was used in the Experimental Fruit Garden, Nagpur. The plantains were set out in rows ten feet apart with eight feet between the plants in the row. The ground was not levelled before planting but the rows were laid out at right angles to the general slope of the ground. A water channel one foot deep and one foot wide at the bottom with sloping sides was dug half-way between the rows. Water was run into this channel until it was nine inches deep. The depth of the water can easily be regulated by a board fitted at the end of the channel. This board is nine inches high so that when the desired quantity of water has flowed into the channel the excess flows over the board into a drain beyond. Should the channel be too long or the slope of the surface of the land such that the channel cannot be filled with water at one time, boards nine inches high should be fitted in the channel at such distances that the water between the boards is nine inches deep. Water was only run into the channels once in ten days and this was quite sufficient to keep the plants growing well. It was not necessary to cultivate the land during the hot weather as the irrigation water never spread over the surface and thus the mulch was not destroyed.

In the rains the channels acted as drains, all that was necessary was to open the channel out. Weeds, etc., were removed whenever there was a break in the rains. Those in the channel were hand-weeded or cut over while the surface between the channel and the trees was cultivated by a double hoe, one bullock walking on either side of the channel. The advantages of this method of irrigation are: (1) Water is saved because there is less evaporation from the sunk channel than there is from the flat surface of the land; (2) labour is saved because the surface mulch is not destroyed at each irrigation; (3) drainage for the monsoon is provided.

The only new cost is that involved in making the channels. These can be made with the monsoon plough. The plough is worked once up and down the line where the trench is to be. The loose earth is removed by a *phoura* and the plough again worked up and down and the loose earth again removed. In four or at most six journeys the channel is one foot deep. About 100 feet of channel can be made in half an hour in this way at a cost of approximately five annas. Once the channel is deep it will last as long as the plantain plot.

By this method of irrigation it has been possible to fruit all the best of the Bombay varieties in Nagpur. Only one precaution was taken, namely, to remove the sucker from the parent plant at once. This is one of the secrets of success. Only when the parent tree flowered was a sucker allowed to remain to take the place of the parent. [R. J. D. Graham in the *Agricultural and Co-operative Gazette*, March 1917.]

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A SIMPLE PROCESS OF EXTRACTING CASTOR OIL.

IN a note on the castor oil plant published in the *Queensland Agricultural Journal*, Vol. VII, January 1917, a comparatively simple process of extracting the castor oil is suggested for trial by any one interested. It is said that a good oil should result. The process is as follows :—

First cleanse the seeds from fragments of the husks and from dust, and submit them to a gentle heat, not greater than can be borne by the hand, which process makes the oil more fluid and more easily expressed. A whitish, oily fluid is thus obtained, which is boiled with a large quantity of water, and all impurities are skimmed off as they rise to the surface. The water dissolves the mucilage and starch, and the albumen is coagulated by the heat, thus forming a layer between the oil and the water. The clear oil is then removed, and boiled with a small quantity of water until aqueous vapour ceases to rise and a small quantity taken out in a phial remains perfectly transparent and cool. The effect of this is to clarify the oil and rid it of volatile acid matter. Care is

necessary not to carry the heat too far, as the oil would acquire a brownish colour and an acid taste.

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EUCALYPTUS TREES AND MALARIA.

S. L. Bostin writes in the "Scientific American":—

"During the later decades of the nineteenth century it was a common practice to plant blue-gum or eucalyptus trees in the districts infected by malarial fever. It was held that the essential oil produced by the leaves combated the harmful vapours rising from the swamps, laden with the poison of the disease. The discovery that the malarial germ is introduced into the blood by a mosquito has settled once and for all the origin of the disease.

"Yet it is only within the last few months that a somewhat mysterious point has been fully settled. The theory that the eucalyptus trees neutralized the poison vapours is nonsense; yet the fact remains that where blue-gums were freely planted there was always a notable decline in the amount of malaria. For instance, in a certain district near Algiers, the placing out of thousands of eucalyptus trees completely transformed the conditions. Malarial fever of a peculiarly virulent type had formerly been a constant feature, but within twelve months of the planting of the blue-gums the disease entirely disappeared and is now unknown.

"What is the explanation of this circumstance? It has been demonstrated that of nearly all trees the eucalyptus absorbs the greatest amount of water. Seeing that blue-gums increase in height with great rapidity, often growing many inches a day in a hot position, the amount of moisture taken up increases on a greatly progressive scale. And this is just what brings about the downfall of the malarial mosquito. To complete its life cycle it is necessary that this insect should pass its larval stage in pools of water. With the coming of the eucalypti these pools and indeed all marshy places disappear; the breeding spots of the mosquitos are gone, and in time the insects vanish altogether. The district is then free from malarial trouble simply because the carriers of the disease are not able to keep going."

Nature, dated 22nd March, 1917, records the deaths of **Major Sydney Donville Rowland**, R.A.M.C., M.R.C.S., the well-known English bacteriologist, at the early age of 45, and of **Charles Achille Muntz**, the distinguished French agricultural chemist.

By the death of Major Rowland, the science of bacteriology has lost a most devoted worker. After studying natural science at Cambridge and medicine at St. Bartholomew's Hospital, Sydney Rowland joined the Lister Institute as assistant bacteriologist and he remained a member of the staff of the Institute until his death. His earlier researches were concerned with the structure of bacteria and the study of various enzymes which Hedin and he discovered in the expressed juices of animal cells. Later on in conjunction with the late Dr. MacFadyen he carried on a lengthy research for finding out curative sera for typhoid and other diseases (but the main object was not attained). In 1905 he came to India as a member of the Plague Commission and took an active part in establishing the dependence of the human epidemic of plague upon the rat epizootic and the importance of the rat flea in the spread of the disease. On his return to England he worked upon the problems of plague immunity, with a view to improve the methods of prophylactic inoculation, and published a number of papers. While still engaged on this work in 1914 the call of his country came and he obtained a commission in the R.A.M.C. and went to the Western Front. While there, he was engaged in discovering meningo-coccus "carriers" amongst troops, but contracted the disease himself and succumbed. He was interested in almost all departments of scientific activity and his death will be mourned by a large circle of friends.

CHARLES ACHILLE MUNTZ will always be remembered as one of the initiators of a striking investigation which laid the foundations of a new branch of science - soil bacteriology. In 1878 he and Schloessing proceeded to ascertain what it was that led to the formation in soil of nitrates from nitrogenous organic compounds. These investigators began by measuring the amount of nitrification taking place when dilute sewage was allowed to trickle down a tube packed with chalk and found that no action occurred for 21 days, but then

it suddenly set in. This could be explained only on the theory that the process was biological. Although Muntz did not proceed further with the work, others took it up and it led to the establishment of the science of soil bacteriology. His other investigations were not less noteworthy. He was well-known for his investigations on air, soil and agricultural products generally and has written an admirable book on manures.—[J. MACKENNA.]

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THE WORLD'S WHEAT CROPS.

THE latest issue of the Bulletin of Agricultural Statistics published by the International Institute of Agriculture at Rome shows that in 1916-17 there were harvested in Argentina, Australia, and New Zealand about 61,581,000 quintals,* as compared with 97,864,000 in the previous year, and 67,080,000, the average for the five years 1909-13, the decline being due to an exceptionally small crop in Argentina. As regards the sowings of winter wheat, the United States show an increase of 2·3 per cent., Spain 3 per cent., Switzerland 5 per cent., and India 8 per cent., as compared with the previous year. On the other hand, France and England show a decline of 15 per cent. The area sown in Japan is unaltered. Spring sowings have hardly begun, and crop conditions are said to be about the average.—[*The Economist*, dated 31st March, 1917.]

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THE PUNJAB AGRICULTURAL COLLEGE, LYALLPUR.

THE Agricultural College at Lyallpur is yearly increasing in popularity: last month over 200 candidates applied for entrance to the new course which opens in July. This number was considerably in excess of previous years' figures. The educational and general standard of the candidates is also considerably higher than it used to be. All the men who completed their course at the college

10 quintals=0 9842 ton.

last year have now got appointments, whether with Government or with private employers : eight men who have passed through either three years' or the two years' course at the college are now in private employment in the Province as managers of estates, and the demand for these men is increasing daily.—[*Punjab Agricultural Notes*, May 1917.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

OBITUARY.

We deeply regret to record the death of Mr. J. H. Barnes, B.Sc., F.I.C., F.C.S., Imperial Agricultural Chemist, which sad event took place at Pusa early in the morning of the 2nd June, 1917. We offer our heartfelt condolences to Mrs. Barnes in her bereavement.

AGRICULTURAL EDUCATION CONFERENCE.—The following gentlemen were invited to take part in the conference on agricultural education which was held in Simla on Monday, June 18th and following days. The Hon'ble Sir Claude Hill, K.C.S.I., C.I.E., I.C.S., Member in charge of the Revenue and Agricultural Department of the Government of India, presided:—

THE HON'BLE MR. R. A. MANT, B.A., I.C.S., Secretary to the Government of India, Department of Revenue and Agriculture.

MR. J. MACKENNA, C.I.E., M.A., I.C.S., Agricultural Adviser to the Government of India.

THE HON'BLE MR. F. G. SLY, C.S.I., I.C.S., Commissioner, Nagpur Division, Central Provinces.

MR. H. M. LEAKE, M.A., F.L.S., Principal. Agricultural College, Cawnpore.

THE HON'BLE MR. C. A. H. TOWNSEND, B.A., I.C.S., Director of Agriculture and Industries, Punjab.

SIR GANGADHAR MADHO CHITNAVIS, K.C.I.E., Nagpur.

MR. DAULAT RAM SETHI, M.A., B.SC., Deputy Director of Agriculture, Bihar and Orissa.

DR. H. H. MANN, D.SC., M.SC., F.I.C., Principal, Agricultural College, Poona.

MR. R. W. B. C. WOOD, M.A., Principal, Agricultural College, Coimbatore.

THE HON'BLE MR. H. SHARP, C.S.I., C.I.E., M.A., Education Commissioner with the Government of India.

MR. C. W. WADDINGTON, C.I.E., M.V.O., M.A., Principal, Mayo College, Ajmer.

THE HON'BLE MR. V. S. SRINIVASA SASTRI, Madras.

THE HON'BLE RAJA SIR RAMPAL SINGH, K.C.I.E., of Korri Sudaili, United Provinces.

THE HON'BLE SIR PRABHASHANKER DALPATRAM PATTANI, K.C.I.E., of Bhavanagar.

RAI BAHADUR LALA GANGA RAM (P. W. D. retired), Lahore.

THE HON'BLE MR. BHUPENDRA NATH BASU, Calcutta.

MR. S. HIGGINBOTTOM, M.A., B.Sc., Ewing Christian College, Allahabad.

BRIGADIER GENERAL C. F. TEMPLER, Director General, Army Remount Department.

COLONEL F. W. HALLOWES, Director, Military Dairy Farms.

D. CLOUSTON, M.A., B.Sc., Officiating Director of Agriculture, Central Provinces.

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THE Tenth Meeting of the Board of Agriculture in India will be held at Poona from the 10th to 15th December, 1917. The following subjects will be discussed at this meeting.

I. Programmes of work of the Imperial Department of Agriculture and of the Imperial Bacteriologist.

II. Programmes of work of the Provincial Agricultural and Veterinary Departments and of Native States Departments of Agriculture.

III. Discussion of a proposal to hold Sectional Meetings of the Board of Agriculture in years in which a meeting of the full Board is not held. Formulation of a programme if the scheme is accepted.

IV. Veterinary Education.

V. The question of summarizing and indexing agricultural publications.

VI. The Indian Sugarcane Industry.

VII. The value of phosphatic manures in India and the possibility of arranging for the manufacture of superphosphates on a larger scale in India so as to lessen their cost.

VIII. The best means of bringing improved methods of agriculture to the notice of cultivators.

IX. To consider whether anything can be done to remedy the disability of agriculture over a large part of India arising from the fact that the size and distribution of the land holdings are such as to render them essentially uneconomic units.

X. A general discussion of the methods of publications by the Department—Imperial and Provincial.

XI. *Experimental error.*—The necessity for research into the subject of experimental error in agricultural experiments with a view to laying down the principles which should be followed in designing such experiments in India and in drawing conclusions from the results obtained. The possibility of constituting a permanent Committee of experts to criticise the reports on agricultural experiments from this point of view.

XII. What action can profitably be taken by Government to discourage the adulteration and mixing of agricultural produce ?

XIII. The best means of rapidly increasing the out-turns of food crops by methods within the power of the Agricultural Department.

XIV. The necessity for legislation regarding the sale of fertilizers in India on lines analogous to, though not necessarily identical with, those of the Fertilizers and Feeding Stuffs Act now in force in the United Kingdom.

XV. Whether all the useful data on manuring and tillage now available as the result of the experimental and research work carried out by the Departments of Agriculture in India should be published for general information and whether a working committee should be appointed by the Board to get this done.

XVI. The necessity for further investigation into the water requirements of crops. The advisability of laying down proposed lines of investigation for different tracts of India, especially irrigation tracts.

XVII. Agricultural Education (the consideration of the policy laid down by the Conference on Agricultural Education at Simla on 18th June 1917 and the best methods of giving effect to it.)

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HIS MAJESTY THE KING-EMPEROR has been graciously pleased to confer the honour of Companion of the Order of the Indian Empire on Mr. J. Mackenna, M.A., I.C.S., Agricultural Adviser to the Government of India.

We offer our hearty congratulations to Mr. H. R. Crosthwaite, Registrar of Co-operative Societies, Central Provinces and Berar, who has been admitted a Companion of the Order of the Indian Empire.

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The services of Mr. J. N. Sen, M.A., F.C.S., Supernumerary Agricultural Chemist in the Imperial Department of Agriculture, Pusa, have been placed at the disposal of the Government of the United Provinces, with effect from the 14th April, 1917, to carry on analytical and special medical work at the Ghazipur Opium Factory.

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The Hon'ble the Chief Commissioner of the Central Provinces has accepted the resignation of Mr. R. J. Harvey, B.Sc., Assistant Director of Agriculture, with effect from 24th March, 1917, on account of ill-health.

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Mr. F. J. Warth, M.Sc., Agricultural Chemist, Burma, has been granted privilege leave for two months from the 1st April, 1917, or the subsequent date on which he may avail himself of it.

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Mr. C. G. Leftwitch, B.A., I.C.S., Director of Agriculture and Industries, Central Provinces and Berar, has been granted privilege leave for three months from the 27th March, 1917.

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Mr. D. Clouston, M.A., B.Sc., Deputy Director of Agriculture, Southern Circle, Central Provinces, has been appointed Officiating Director of Agriculture and Industries, Central Provinces and Berar, *vice* Mr. C. G. Leftwitch on privilege leave.

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His Majesty's Secretary of State for India has sanctioned the re-engagement of Mr. W. A. Davis, B. Sc., Indigo Research Chemist, for a further period of five years.

MR. D. T. CHADWICK, M.A., I. C. S., (lately Director of Agriculture, Madras), who was recently on a deputation to Russia, France, and Italy with a view to promoting commercial relations between India and those countries, has been appointed the first Indian Trade Commissioner in London.

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M. R. RY. J. CHELVARANGA RAJU GARU, acting Deputy Director of Agriculture, IV Circle, St. Thomas' Mount, Madras Presidency, has been granted privilege leave for two months and fourteen days from or after the 28th May, 1917. Mr. H. C. Sampson, B.Sc., Deputy Director, V and VII Circles, will hold charge of the IV Circle in addition to his own.

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MR. H. M. CHIBBER, M.A., Assistant Professor of Botany, Agricultural College, Poona, has been appointed to act as Second Economic Botanist, Bombay Presidency, pending further orders.

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MR. G. B. PATWARDHAN, Assistant Economic Botanist, Bombay Presidency, has been appointed to act as Assistant Professor of Botany, Agricultural College, Poona, *vice* Mr. H. M. Chibber, or pending further orders.

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MR. T. F. QUIRKE, M.R.C.V.S., is posted as Superintendent, Civil Veterinary Department, North-West Frontier Province and North Punjab Circle.

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MR. F. WARE, M.R.C.V.S., Superintendent, Civil Veterinary Department, Madras, has been granted combined leave for one year from the 14th February, 1917. Mr. D. A. D. Aitchison, M.R.C.V.S., Principal, Madras Veterinary College, is in charge of the office of the Superintendent, Civil Veterinary Department, in addition to his own duties.

THE spread of *Lantana* in India and Burma has attained such proportions that it has become, or is becoming, a serious problem in many districts, so much so that in Coorg it has already been found necessary to legislate especially for its control. In view of the successful control of this plant in other parts of the world, notably in Hawaii, by the introduction of insects which attack *Lantana* and thereby check its growth and spread, it has been proposed that such insects might usefully be employed in India. But before introducing any such insects from abroad, it has been considered advisable to see whether we have not already in the Indian Empire any insects which could be used successfully for this object, and, with this end in view, **Mr. Y. Ramachandra Rao, M. A., Entomological Assistant in the Madras Department of Agriculture, has been deputed, for a period of two years in the first instance, to work at this problem under the Imperial Entomologist.** Mr. Ramachandra Rao will travel throughout India and Burma and make a close study of the various insects found on *Lantana* and of any factors favouring or limiting its spread in different districts, so that information will be available to enable the problem of its control to be taken up on the broadest basis.

The Imperial Entomologist will be very pleased to receive any authentic detailed observations regarding the entry, spread or disappearance of *Lantana*, or specimens of any insects found attacking it, in any localities within the Indian Empire.

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TOWARDS the close of last year the Pumping and Boring Section of the Department of Industries, Madras, was incorporated into the Department of Agriculture. A new section, called the "Agricultural Engineering Section," has thus been formed under the Director of Agriculture, Madras. The *personnel* consists of :-

An Agricultural Engineer—Mr. F. T. T. Newland.

An Assistant Engineer—M. R. Ry. V. Rangachariar, Avl.

Ten supervisors with headquarters at Vizagapatam, Bezwada, Madras (for Chingleput Circle), Cuddalore, Tanjore, Trichinopoly, Tinnevelly, Coimbatore, Vellore, and Gooty.

Assistance will be given to the ryots in well-boring and blasting, and in the erection of pumping, cotton ginning, rice hulling, and other machinery.

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THE Department of Fisheries in Bengal has been separated from that of Agriculture, the head of the Department being designated Director of Fisheries.

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SINCE the publication of the list in the last January issue of this Journal the services of the following officers have been placed temporarily at the disposal of the Government of India in the Army Department with effect from the dates noted against their names.

1	D Meadows, M.R.C.V.S., I.C.V.D., Superintendent, Civil Veterinary Department, North Punjab and North-West Frontier Province, Rawalpindi .. .	19th April, 1917
2	W. A. Pool, M R C V.S, I.C.V.D, Post-graduate Professor, Veterinary College, Lahore	27th February, 1917.

The following Veterinary Assistants from the Central Provinces are also temporarily employed on military duty.

1.	B. B Ghosh, Veterinary Assistant			. 42nd Mule Corps, Meerut.
2.	P S Sundoram	,,	,,	4th Government Camel Corps, Campbellpur.
3.	Ahmad Alikhan	,,	,,	... No. 4, Mule Depôt, Karachi.
4	Inayat Khan	,,	,,	Do.

Reviews.

The Co-operative Movement in India.—By PROFESSOR P. MUKHERJI, M.A., F.R.E.S., Second Edition. pp. 453 + xxi. Price Rs. 4-8. Published by Thacker, Spink & Co.

WE congratulate Professor Mukherji on the success which has attended his careful study of the co-operative movement in India. In our review of Mr. Crosthwaite's book which appears in the earlier pages of this Journal we have dealt with the work of the practical co-operator. In Professor Mukherji's work we have a presentation of the subject by a recognized authority on economics, and we venture to think that he has succeeded in producing a volume which will be useful not only to the practical co-operator but also to the student of economics who will find therein not only a lucid explanation of the underlying principles but also a practical application of the abstract theories of co-operation. The book is written with the precision of arrangement and logical sequence which one expects from the scientific economist. But the dry bones of the economic principles underlying the movement are constantly made to live by the personal appreciation of their practical application which the writer never fails to grasp. For instance, what better summing up than this?

"The rural credit co-operative societies in India are now numbered by the thousand; with their aid labourers have become owners; hopeless debt has been banished and the *mahajan* driven out; agriculture and industry have been developed, and the villagers in the poorest tracts have become prosperous; the illiterate man has turned towards education and the drunkard has been reclaimed; the middleman has been eliminated, the *raiyat* is getting full value for his produce, and paying his rent with ease; village life has been

stimulated by associated action and by the business education of the Bank; punctuality, thrift, and mutual confidence are being taught, litigation has decreased and morality has improved; activity has taken the place of stagnation and routine; associated action has replaced mutual distrust."

This extract shows that Professor Mukherji has the truth of the matter in him and that he can give the bald theories of the abstract economist their true human application.

From the point of view of the practical co-operator Professor Mukherji's annotation of the Co-operative Societies' Act of 1912 is of the greatest value. We warmly commend this volume either as a text-book for the student of political economy or to the practical co-operator and the general reader as a careful and sympathetic study of the co-operative movement in India. [J. M.]

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Handbook of Agricultural Leaflets.—By G. EVANS, M.A., Deputy Director of Agriculture, Northern Circle, Central Provinces and NAND KISHORE, L. AG., Extra Assistant Director of Agriculture, Central Provinces, Jubbulpore. Second Edition, pp. 166. Price 5 annas.

THIS handbook, which is published in Hindi and is intended for the northern parts of the Central Provinces, contains a number of practical hints on agriculture. The leaflets deal with simple improvements, and nothing is advocated which is beyond the means of the ordinary tenant-farmer. The appendices at the end of the book, which contain tables of weights and measures and a list of Indian *nakshatras* or lunar mansions, with equivalent periods according to Hindu and English calendars, showing the time when various crops are to be sown and cut, add to the usefulness of the book. As the handbook comprises 166 pages and several illustrations the price of five annas per copy is only nominal, and the fact that the first edition of 1,000 copies rapidly sold out and a second edition of 3,000 copies has been issued, shows the popularity of the publication. It is hoped that the Agricultural Departments in other provinces will also bring together from time to time the leaflets

issued by them and publish them in book form in the vernacular at a cheap price, if they have not already done so. This effort of Messrs. Evans and Nand Kishore is worthy of all praise as it undoubtedly is proving of the utmost assistance to the real cultivating classes.—[EDITOR.]

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Handbook of Information, 1917.—Issued by the SCIENTIFIC DEPARTMENT OF THE INDIAN TEA ASSOCIATION, Calcutta. Printed at the Criterion Printing Works, 8, Jackson Lane, Calcutta.

WE have much pleasure in noticing this little handbook of 33 pages. It is intended to serve as a guide to the tea planters of Assam and also to the general public. It shows in brief compass what constitutes the staff of the Scientific Department employed by the Indian Tea Association, where it is located, what are the principal Experiment Stations, where they are situated and what work is being done by the various experts. Practical hints on sending specimens of insects, specimens attacked by fungus diseases, and plants for identification add to the usefulness of this publication. But in our opinion the most valuable portion of the book consists in the descriptions of various kinds of green-manuring plants and shade trees with practical hints as to how they are to be sown and dealt with as also the places where the seeds can be obtained. The only criticism we have to make is regarding the size of this publication. In our opinion the octavo size would have been more suitable. The issue in English and Vernacular of such handbooks or calendars appears to us to be very desirable in the case of Agricultural Departments as it is one of the ways of awakening interest among the public and thereby facilitating the work of the Department.—[EDITOR.]

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THE January (1917) number of the **Poona Agricultural College Magazine,** which is issued quarterly, contains among other papers, one on "Studies in Leguminous Plants" by Mr. Gangulee and another on "Our Agricultural Associations" by Mr. Inamdar. In view of the well-known shortage in some parts of this country

of farmyard manure which is the most natural and convenient source for the supply of nitrogen to a growing crop, the first paper is of some interest in that it is a preliminary study of some aspects of nitrogen fixation in certain of the leguminous plants suitable for green manure. In the second paper on "Our Agricultural Associations" Mr. Inamdar suggests the engaging of a whole-time organizer for each Agricultural Association in order to enable the Association to perform its duties efficiently and to awaken interest among cultivators. He tries to meet the objections that might be raised against his suggestion and states in conclusion that an organization of the Associations on federal lines seems to be highly advisable. His scheme of Taluka, District and Provincial Agricultural Associations looks attractive on paper, but it is very doubtful how far it is feasible in India.—[EDITOR.]

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WE have received for review a copy of the January (1917) issue of the **Journal of the Madras Agricultural Students' Union.** This Journal has been six years in existence and during this short period it has undergone several changes. It first made its appearance as a modest year-book and then became a quarterly. From November 1914 it is being issued monthly, the subscription price being only Rs. 2 per annum. It is in touch with the Madras Department of Agriculture (to whose fostering care it owes its present success), with the landed aristocracy of the Presidency, and with practical farmers. In the issue under review, we would recommend for perusal the articles on the cotton trade of Nandyal and arrowing in sugarcane and a note on the utilization of the water hyacinth for commercial purposes. The Journal usually contains good reading matter, and we hope it will become more and more popular, as it deserves to be, among those for whom it is intended.—[EDITOR.]

Correspondence.

To the Editor,

The Agricultural Journal of India.

Sir,

In the January number of your Journal there is a statement by Howard and Howard on p. 42, that Indian milk is "inferior both in quality and quantity to that which would be possible if the albuminoid ratio of the fodder could be improved." Such loose statements are regrettable. There is very little evidence to show that feeding will improve the *quality* of the milk: in fact most experimental work has given a negative result. In any case, the quality of Indian milk leaves little to be desired: it is extremely rich. The quantity, of course, is wretched, but better feeding will not improve this, as the animals will promptly put on weight.

Yours faithfully,

February 22, 1917 Dairyman.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

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1. Medical and Veterinary Entomology: A Text-book for use in Schools and Colleges, as well as a Handbook for the use of Physicians, Veterinarians, and Public Health Officials, by William B. Herms, Associate Professor of Parasitology in the University of California, etc., Author of "Malaria, Cause and Control," etc., Fully Illustrated. Price 17*s*. net.
2. British Agriculture: The Nation's Opportunity, by the Hon. E. G. Strutt, L. Scott, and G. H. Roberts, and a Preface and Appendix on the Reclamation of Land, by A. D. Hall. Pp. xi + 168. (London: J. Murray.) Price 3*s*. 6*d*. net.
3. The Lack of Science in Modern Education, with Some Hints of What Might Be, by Sir Napier Shaw. Pp. 42. (London: Lamley & Co.) Price 1*s*. net.
4. Recent Researches in Plant Physiology, by W. R. G. Atkins. (London: Whittaker & Co.) Price 7*s*. 6*d*. net.
5. Recent Progress in the Study of Variation, Heredity and Evolution, by R. H. Lock. Revised by L. Doncaster. Fourth Edition, with portraits and diagrams. (London: John Murray.) Price 6*s*. net.
6. Laboratory Methods in Agricultural Bacteriology, by Prof. Dr. F. Lohnis: Translated by W. Stevenson of the West of Scotland Agricultural College and J. Hunter Smith. Pp. i—xi + 136. (London: Charles Griffin & Co.). Price 4*s*. 6*d*. net.
7. Elementary Agricultural Chemistry, by Herbert Ingle. Second Edition. Pp. i—ix + 250. (London: Charles Griffin & Co.) Price 4*s*. 6*d*. net.

8. Dairy Chemistry: A Practical Handbook for Dairy Chemists and others having Control of Dairies, by H. Droop Richmond. Second Edition. Enlarged. (London: Charles Griffin & Co.) Price 15*s*. net.
9. Botany: A Text-book for Senior Students, by D. Thoday. Pp. xvi + 474. (Cambridge: At the University Press, 1915.) Price 5*s*. 6*d*. net.
10. Some Recent Researches in Plant Physiology, by Dr. W. R. G. Atkins. Pp. xi + 328 (London: Whittaker & Co., 1916.) Price 7*s*. 6*d*. net.
11. Outline of Lectures in Special Pathology, by Sammuel Howard Burnett, Professor of Comparative Pathology in the New York State Veterinary College at Cornell University, Ithaca, New York. (London: Macmillan & Co., Ltd.) 8vo. Price 5*s*. 6*d*. net.
12. Veterinary Obstetrics (including the Diseases of Breeding Animals and of the New Born), by W. L. Williams, Professor of Surgery and Obstetrics in the New York State Veterinary College at Cornell University. Illustrated. (London: Macmillan & Co., Ltd.) Royal 8vo. Price 34*s*. net.
13. Surgical and Obstetrical Operations (Veterinary), by W. L. Williams. Third Edition, revised and enlarged. (London: Macmillan & Co., Ltd.) Crown 8vo. Price 10*s*. 6*d*.
14. A Text-book of Histology, by H. E. Jordan and J. S. Ferguson. Pp. xxviii + 799. (London and New York: D. Appleton & Co.) Price 15*s*. net.
15. Horses, by R. Pocock. With an Introduction by J. Cossar Ewart. Pp. x + 252. (London: John Murray.) Price 5*s*. net.
16. Laboratory Manual of General Chemistry with Exercises in the preparation of Inorganic Substances, by A. B. Lamb. Pp. vi + 166. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press.) Price 6*s*. net.
17. The Physiology of Food and Economy in Diet, by William Maddock Bayliss. (London: Longmans, Green & Co.) Price 2*s*. net.

18. A Text-book of Inorganic Chemistry, by J. Newton Friend and other Authors. Second Edition: Revised. Pp. i—xi + 385. Vol. I. (London: Charles Griffin & Co.) Price 10*s*. 6*d*. net.
19. Analytical Chemistry: Based on the German Text of Prof. F. P. Treadwell. Translated and Revised by V. T. Hall. Vol. I, Qualitative Analysis. Pp. xiii + 538 (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1916.) Price 12*s*. 6*d*. net.
20. A method for the Identification of Pure Organic Compounds, by Prof. S. P. Mulliken, Vol. II. Pp. ix + 327. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1916.) Price 21*s*. net.
21. The Standard Cyclopædia of Horticulture, by L. H. Bailey, Vol. III, F.-K. Pp. v + 1201—1760, Vol. IV, L-O. Pp. v + 1761—2421. (New York: The Macmillan Co.; London: Macmillan & Co., Ltd.) Price 25*s*. net each volume.
22. The Small Grains, by M. A. Carleton. Pp. xxxii + 699. (New York: The Macmillan Co.; London: Macmillan & Co., Ltd., 1916.) Price 7*s*. 6*d*. net.
23. A Text-book of Organic Chemistry for Students of Biology, by E. V. McCollum, Professor of Agricultural Chemistry, University of Wisconsin. (London: Macmillan & Co., Ltd.) Price 10*s*. net.
24. Report of the Royal Commission on the Public Services in India. Published in 20 volumes. Vol. XV. Forest and Agricultural Departments. (Available at Messrs. Thacker, Spink & Co., Calcutta.) Price Rs. 2-10 annas.
25. Chemical Discovery and Invention in the Twentieth Century, by Sir William A. Tilden. Pp. xvi + 487. (London: George Routledge and Sons, Ltd.) Price 7*s*. 6*d*. net.
26. A Glossary of Botanic Terms, with their Derivation and Accent, by Benjamin D. Jackson. Third Edition. Pp. xii + 427. (London: Duckworth & Co.) Price 7*s*. 6*d*. net.
27. Illustrations of the British Flora: A Series of Wood Engravings, with Dissections, of British Plants. Drawn by W. H. Fitch

with additions by W. G. Smith. Fourth (Revised) Edition. Pp. xvi + 338. (London: L. Reive & Co., Ltd., 1916.) Price 9s. net.

28. Dairy Farming, by C. H. Eckles, Professor of Dairy Husbandry, University of Missouri, and G. F. Warren, Professor of Farm Management, Cornell University. (London: Macmillan & Co., Ltd.) Price 5s. net.

29. The Method of Enzyme Action, by Dr. J. Beatty. Pp. ix + 143. (London: J. and A. Churchill). Price 5s. net.

30. Chemistry for Beginners, by C. T. Kingzett. Pp. vi + 106. (London: Bailliere, Tindall, and Cox.) Price 2s. 6d. net.

31. A Short System of Qualitative Analysis, by Dr. R. M. Caven. Pp. viii + 162. (London: Blackie and Son, Ltd.) Price 2s. net.

32. The Chemists' Year Book, edited by F. W. Atack assisted by L. Whynates. Two vols. Pp. 1030. (London and Manchester: Sherratt and Hughes).

33. Studies in Insect Life, and other Essays, by Dr. A. E. Shipley. Pp. ix + 338. (London: T. Fisher Unwin. Ltd.) Price 10s. 6d. net.

34. An Introduction to Biology, and other Papers, by A. D. Darbishire. Pp. xviii + 291. (London: Cassell & Co., Ltd.) Price 7s. 6d. net.

35. Geology: Physical and Historical, by Prof. H. F. Cleland. Pp. 718. (New York: American Book Co.) Price 3·50 dollars.

36. Genetics and Eugenics, a text-book for students of biology, and a reference book for animal and plant breeders, by W. E. Castle. Pp. vi + 353. (Cambridge: Harvard University Press; London: Milford.) Price 8s. 6d. net.

37. The Order of Nature, an essay by Lawrence J. Henderson. Pp. v + 234. (Cambridge: Harvard University Press; London: Milford.) Price 6s. 6d. net.

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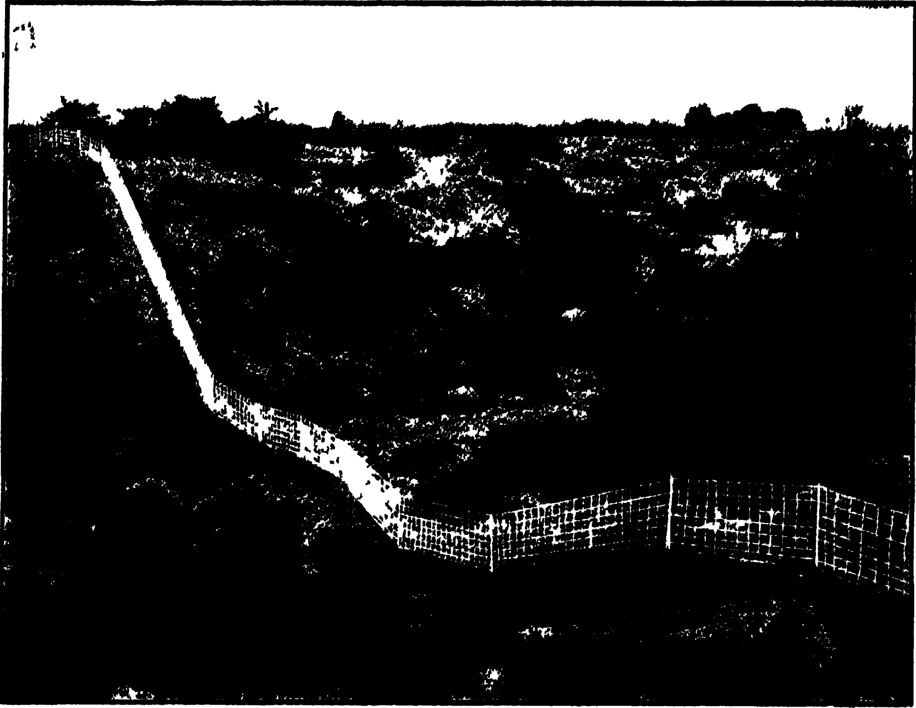
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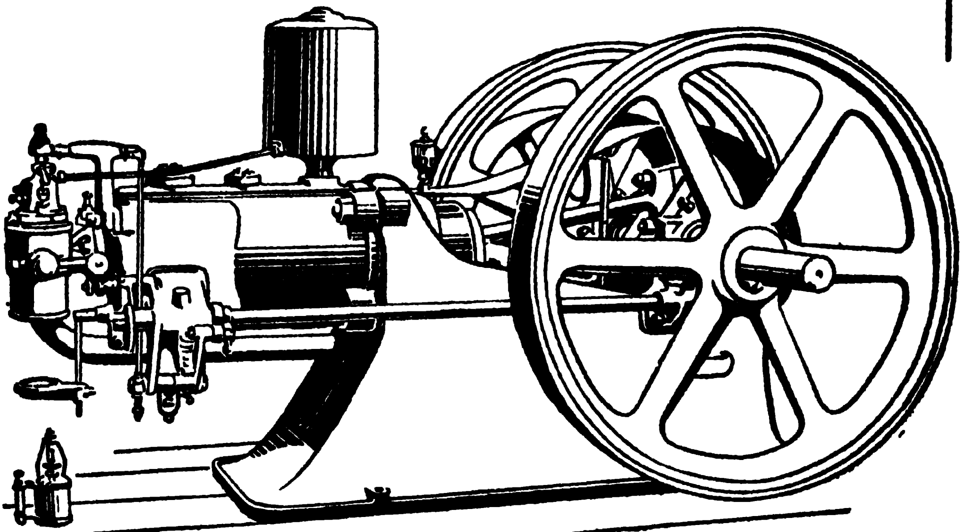
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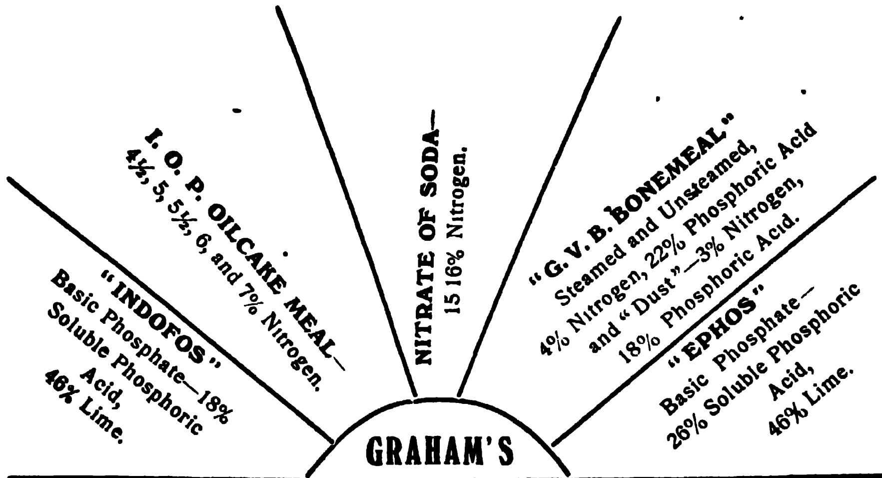
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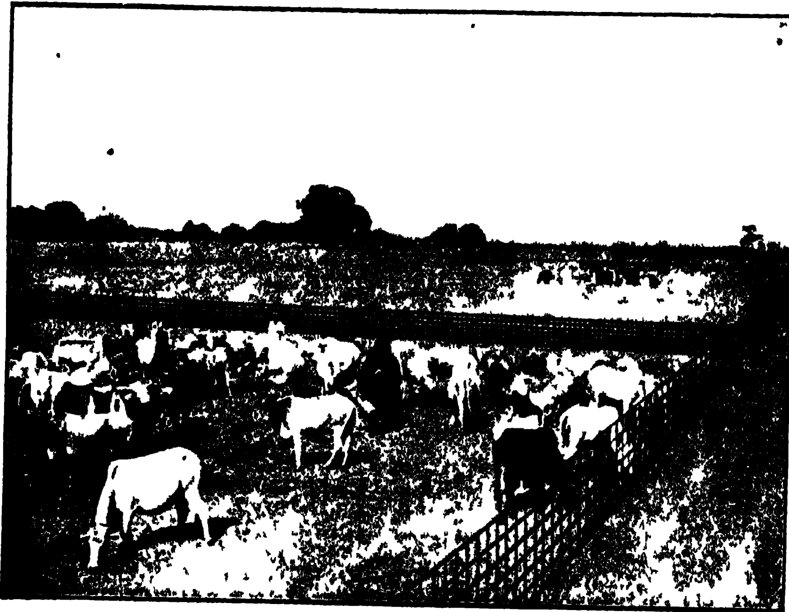
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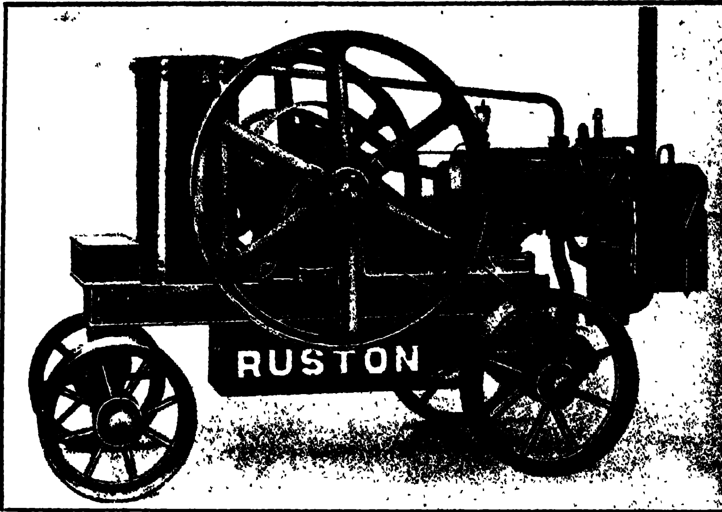
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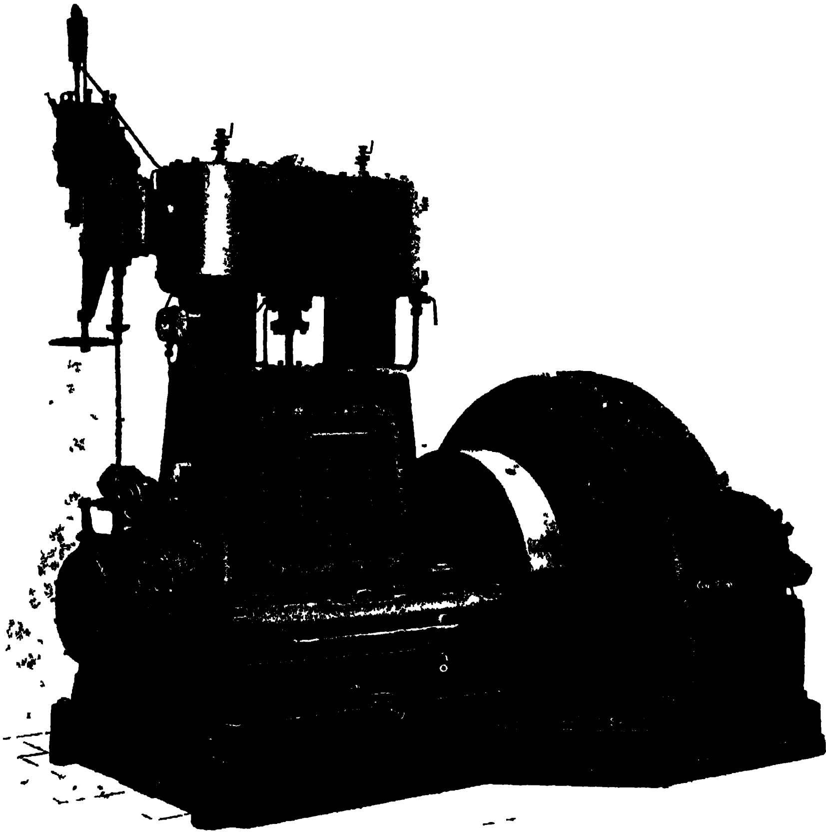
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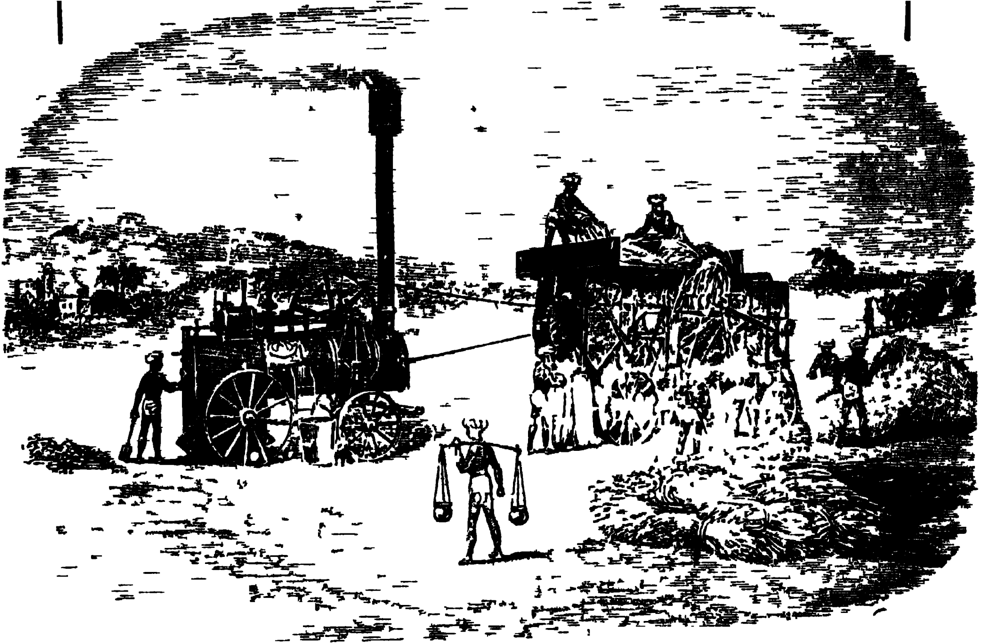


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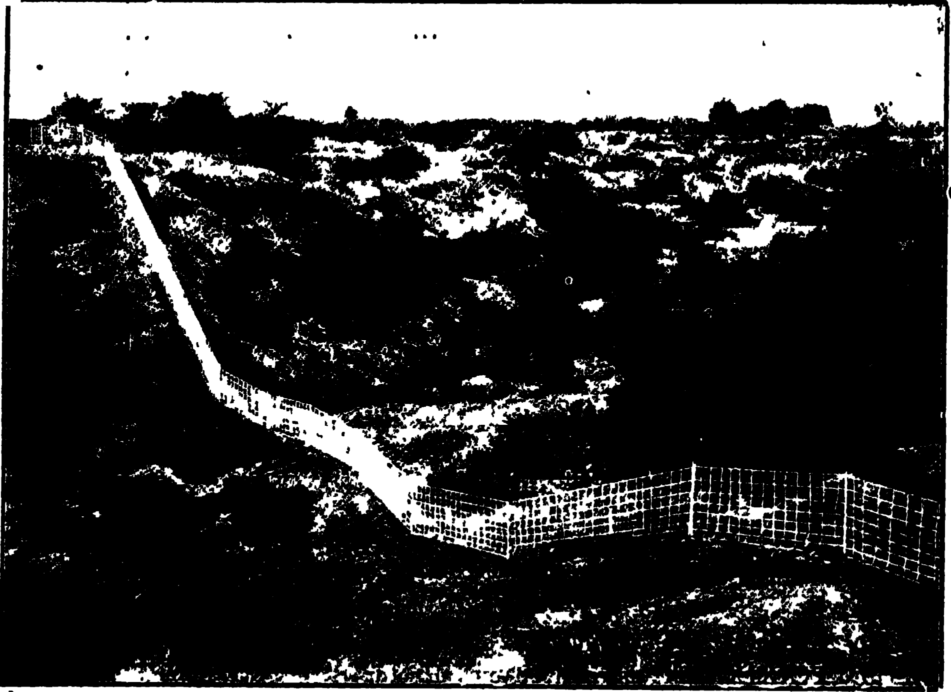
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PRIVATE FARMS IN OUDH.*

BY

THE HON'BLE MR H R. C. HAILEY, C.I.E., I.C.S.,

Director of Agriculture and Land Records, United Provinces

OUDH is a province of large estates. The circumstances which led to the establishment of what is known as the taluqdari system are matters of history; it suffices to quote the fact, as set out in the *Imperial Gazetteer*, that after the Mutiny 22,658 out of 36,721 villages were settled with taluqdars. Further, tenancy rights differ from those of the sister province and the absence of a corresponding system of occupancy rights undoubtedly secures to the Oudh landlord a wider and more powerful influence on his estate. Occupying a semi-feudal position with numerous dependants to support, the Oudh landlords have been in the habit of retaining larger areas in their own cultivation than is the usual custom among the landlords of the Agra province. When the Agricultural Department began to devote itself seriously to improving the agricultural conditions of Oudh it was found essential to interest the taluqdars in the movement.

In the Agra province the Department finds its chief support in the small cultivating zamindars, who are comparatively few in number in Oudh, and the larger occupancy tenants. Wherever demonstration work has extended, both classes have shown readiness to try new implements, varieties of crops, methods of cultivation from which they saw a reasonable hope of increased profit. The

* Received for publication on 6th July, 1917.

Oudh tenantry had neither the enterprise, nor the capital of the occupancy tenants of the Agra province, and were slower in responding to the influence of the Department. Moreover, even if they had shown themselves equally adaptable, there was an obvious advantage in dealing with a large landlord, who could bring his influence to bear on masses of cultivators, rather than with individuals. The first step, too, to be taken is some form of demonstration, and the landlords having land at their disposal were in a position to undertake this on a large scale. They are accordingly invited to open demonstration farms, to be worked in conjunction with the Department, which, as will be subsequently pointed out, serve a number of other purposes and will, it is hoped, develop into model farms, showing the advantages which can be obtained by the proper cultivation of the land.

The existing farms are the growth of the past few years. The Department itself, as now constituted, is not of very long standing. The first years were necessarily devoted to examining agricultural conditions and to experimental work. The principal crops of Oudh are wheat, rice, and sugarcane, somewhat in the order named; while cotton is grown only in the border districts. The question of effecting an improvement in the wheat crop first attracted attention, and there is no doubt that the almost immediate success secured by Pusa No. 12 wheat gave a great impetus to demonstration work. The introduction of a new and decidedly more profitable variety, which requires little change in cultural methods, clearly offers an opportunity for those anxious to do something for improving agriculture. Work on sugarcane commenced somewhat later, and definite results were not secured until a special farm was opened in which indigenous varieties were sorted out and some promising exotic canes tested. The varieties recommended are now being grown on an extended scale on the private farms, but progress is likely to be less marked than in the case of wheat, since a definite improvement of the yield can only follow better methods of cultivation. These farms, therefore, came into existence as experimental work yielded results for demonstration. If started before this preliminary work had been done, they would have served little

useful purpose and their utility will increase in proportion as research and experiment afford more objects for demonstration.

There are at present some 21 of these farms in Oudh, mainly on estates of large taluqdars ; more are being opened and the existing farms extended. The size ranges from about 30 to 200 acres. An obstacle in the way of their expansion is the difficulty in procuring the necessary machinery and pumping plant for working areas of any size. With large blocks under wheat, it is difficult to finish threshing operations by the ordinary country methods before the rains set in. When bullock-driven mills are employed, the area under cane must be limited to their capacity. The Agricultural Department, too, is experiencing considerable difficulty in procuring the material for putting down tube wells and the pumping plant necessary for irrigating farms of any considerable size economically. The opening of farms of over 100 acres on the large Balrampur and Nanpara estates is being delayed on this account. There is every probability that as soon as normal conditions are resumed, not only will some of the existing farms be enlarged, but they will be equipped with the machinery required for farming operations on any scale.

There is no uniform system of management adopted. In some cases a trained fieldman is lent by the Agricultural Department ; in others the taluqdars prefer to send men to be trained on the farms of the Department ; in others only advice is given. In nearly all a close touch is maintained with the Department, and the varieties of crops recommended are grown and demonstration given of particular methods of cultivation. Some of the taluqdars have kindly consented to submit a balance sheet with a view to showing the profits that can be looked for from better methods of farming. The primary object, however, with which most of these farms were established was the improvement of agriculture on the owners' estate. Their principal functions accordingly are to demonstrate the value of certain crops and methods of cultivation, and to distribute reliable seed. The most popular crop has been the Pusa wheat mentioned before, the seed of which has been distributed in very considerable quantities. Where the farms are worked in

close association with the Department, steps are taken to maintain the purity of the seed, and to store it properly during the rainy season. The rapid spread of this wheat throughout parts of Oudh is largely due to the existence of these farms, without which it would not have been possible to obtain sufficient seed for distribution. How valuable this assistance has been can be judged from the fact that in the present year, when there is a scarcity of reliable seed on account of the damage to the grain on the threshing floors in the western districts, the Department has been able to buy back over 2,000 maunds, mainly from the farms of the Raja of Amethi, the Hon'ble Raja Sir Rampal Singh of Kurri Sudhauli, and Raja Partab Bahadur Singh of Partabgarh. This will be available for distribution in the districts where the harvest is later and the damage to the grain from rains in May was serious.

Some simple lessons are also enforced in connection with the growing of this crop. The Oudh seed rate is unnecessarily high, as much as 160 and even 180 lb. being sown to the acre. The reason is partly the reliance of the cultivator on the *bania's* shop for his supply, the excessive rate being an insurance against the bad germination of a very unreliable seed. To show how unnecessary this rate of sowing is with selected seed carefully stored, arrangements have been made at some of the farms to show the results of sowing at different rates and the negative advantages of the common rate of sowing. Mr. Sharma, who has assisted largely in the opening and management of these farms, computes that in his circle only some 16 lakhs would be saved annually were the seed rate reduced to that found sufficient on the Government farms. The question is so far of mainly local interest that agriculturists in other parts of the provinces are more careful in preserving seed, but in Oudh the problem is a more serious one, and it has been found necessary to open considerable numbers of seed depôts to provide reliable seed. Object-lessons of this nature have, therefore, a special value.

Another series of demonstrations are connected with the better cultivation of sugarcane. Figures showing the poverty of the average yields from sugarcane in these provinces have been frequently quoted in various reports dealing with this subject, and it

is unnecessary to repeat them. But, while opinions may differ as to the advisability of introducing new varieties, there can be no question that no improvements are likely to be effected until the crop receives the same measure of attention as is given to it in other cane-growing countries, and indeed, in any other parts of India. At some of these farms, both exotic varieties, such as Ashy Mauritius and J. 33, and the heaviest yielding indigenous varieties are grown on the system recommended by Mr. Clarke, the Agricultural Chemist, under which the ground is either trenched or the crop earthed afterwards. The land is suitably manured, and trials have been made of the various cake manures found successful on the farms of the Department. Yields were obtained during the past season of 60 to 70 maunds of *gur* per acre, which for these provinces is a good yield, and quite double that ordinarily obtained by the slovenly methods of cultivation in common practice. At current prices the profits obtained were high and support the contention that the additional outlay involved is amply repaid in increased returns. The cultivation of groundnuts, comparatively recently introduced in these provinces, is becoming popular. The seed of selected varieties has been handed on to these farms and is distributed in turn to the tenants. Though other crops are grown, demonstration is mainly concentrated on Pusa wheat, sugarcane, and groundnuts. Some selected varieties of rice have been grown which, being true to type, give a heavier yield than the somewhat mixed crop ordinarily grown and, as experimental work on improved methods of rice cultivation proceeds, these farms should be useful in demonstrating the results. On several farms power-driven pumping plant has been installed. Such installations are mainly for capitalists. But if widely adopted they could, with tube wells, convert large precarious tracts in Oudh into first class wheat-growing land. There are also large areas of mild *usar* in Oudh which experiments, undertaken in co-operation with one landlord, seem to show could, with a plentiful water supply, be sufficiently improved to be taken up by tenants. These are some of the directions in which mechanical power could be employed with great advantage to the agriculture of Oudh, and pioneer work is to be welcomed.

These private farms, as has been mentioned above, have only recently been started and are still in the developing stage, but if interest in them is maintained and the movement, as there is good reason to believe will be the case, spreads, they have great possibilities of usefulness. They will supply a non-official agency for taking over approved varieties for multiplication and distribution, and there should be no great difficulty in making arrangements for maintaining purity. By doing so they will relieve the Department of a branch of work which lies somewhat outside the recognized duties of an Agricultural Department and presses heavily on its small staff. A well managed farm in each estate would do much to promote the substitution of better classes of wheat and so increase the total provincial yield.

But they can be made to serve even wider purposes. If run on sound lines they could act as complements to the farms of the Agricultural Department. One of the most difficult tasks before a body of experts is to persuade the agricultural community that their recommendations are practical and not merely theoretical; that they are not beyond the means of the agriculturist with small capital, and that they will repay any additional expenditure involved. If a person occupying the position of a big landlord, who does not claim any special expert knowledge, finds that he can carry them into effect with a profit to himself, he cannot fail to influence in their favour the smaller and less enterprising agriculturist. In this connection Mr. Howard, the Imperial Economic Botanist, after visiting one of these farms, noted that the value of the example seemed to him very great at the present time. "It is most useful," he added, "as showing how Oudh can be developed—it proves that agriculture on modern lines pays well under Indian conditions and supplies an answer to those critics of the Agricultural Department who say that the work on Government farms leads to little of practical importance." Economic conditions differ widely in different provinces and in each different methods will probably have to be adopted for reaching the mass of small cultivators. So far as Oudh is concerned, these private farms seem to offer an excellent means to this end.

ICERYA PURCHASI IN CEYLON: A WARNING TO INDIA.*

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist.

INFORMATION has recently been received from the Government of Ceylon to the effect that *Icerya purchasi* has become established in that Colony, and a leaflet(35)† issued by the Ceylon Department of Agriculture gives further information, whereby it appears that this pest was first discovered in December, 1915, on *Acacia decurrens* on an estate in the Agrapatnas, Central Province, and that by October, 1916, it had increased in numbers and spread on to *Acacia dealbata*. In August, 1916, it was discovered in enormous numbers in an Acacia forest at Ambawela, and subsequently was found on Acacias at Galaha and Upper Hewaheta, appearing also on Citrus trees at Galaha. It has apparently also been found on other trees at Kandy. It thus becomes apparent that *Icerya purchasi* has obtained a firm footing in Ceylon and has evidently been present in that island for some time.

Our readers will ask :—What is *Icerya purchasi* and what has the fact of its presence in Ceylon got to do with us in India ? To these questions it may be replied briefly that *Icerya purchasi* is an extremely destructive Scale-insect, whose original home was Australia but which has now been spread almost all over the world, causing great destruction, especially of Citrus trees, and that the fact of its occurrence in Ceylon increases the probability of its introduction

* Received for publication on 6th August, 1917.

† The numbers in brackets refer to the literature cited.

into India, if it has not already been brought in—which is not the case, so far as we know at present.

The original home of *Icerya purchasi*, as noted above, was Australia and probably Victoria according to French(3), who states that it was common throughout that Colony about, or even prior to, the year 1860. During the last half century, however, it has been imported into other countries until at the present day its distribution embraces Australia, Asia, Africa, Europe, and North America, and in every continent it has proved a most serious pest. It was introduced into South Africa at Cape Town in 1872 or early in 1873 ; it was certainly present in the Botanic Gardens at Cape Town in 1873 and by 1877 had spread widely in Cape Colony(27). It has since been recorded in the (late) German territory in South-West Africa(12), in Rhodesia(21, 29), in British East Africa(20), and in Zanzibar(9), so that the whole of the fruit-growing areas of South and East Africa are now infected.

In the Mediterranean Region, its first appearance seems to date from the year 1873, when it was found in Portugal(28) and its predator, *Novius cardinalis*, must have been introduced some time thereafter, as Mendes(13) records the discovery of *Icerya* and *Novius* in Portugal in 1910. Spain appears to be free as yet, although the absence of records does not prove the non-existence of this pest. Italy apparently became infested about twenty years ago, and by 1900 *Icerya purchasi* had attained a footing around Naples, and thence it was introduced into Sicily and in 1912 was reported(11) to be gaining fresh ground daily in the orange groves of that island. From Sicily this pest found it but a step to invade Malta which was reported(16) as severely infested in 1912. Having attained a firm footing in the Mediterranean Region, *Icerya* was not long in spreading to Asia Minor, where it was already doing serious damage in 1912 in Adalia to groves of mandarin oranges and lemon trees(15), to Scio, whose orange groves had been seriously damaged before that(15), and to Egypt, where the presence of *Icerya* is noted in Dr. Gough's paper issued in 1914(22).

Icerya purchasi was introduced into the United States from Australia in 1868(28) and in 1880 was found doing serious damage





ICERYA PURCHASI.

Fig 1

Icerya purchasi on branch of orange, young on leaves, adult females on twig, and winged male (From French's *Handbook of the Destructive Insects of Victoria* Part II, Plate XX)

Fig 2

Icerya purchasi clustered on orange twig, about natural size. (From Essig's *Injurious and Beneficial Insects of California,* Fig 70).

to orange trees at Santa Barbara in California(2) and as spreading with amazing rapidity, and even at the present day it is a serious pest in California(6). In the orange-growing districts of Florida, it seems to have been first found at Tampa in 1911(10) and has since been reported as slowly spreading(24, 33). In 1913 it was discovered in Louisiana near New Orleans(19) ; prompt measures were taken and it was reported as successfully controlled. The West Indies and South America appear to be free so far. In Chile, for example, only one species of *Icerya* is known(31) and this is not *Icerya purchasi.*

The Hawaiian Islands were apparently infested directly from Australia some forty or more years ago. Kirkaldy in 1904(4) notes that this Scale was " formerly destructive, but since the introduction of the ladybirds............, it is of little importance, only occurring sporadically." *Novius* was introduced into Hawaii in 1890(26).

Asia is the latest of the great continents to be invaded by this pest, its presence in Ceylon having been reported quite recently(35), as noted above.

Icerya purchasi is especially a pest of all Citrus trees but may also occur on numerous other trees and plants, amongst which may be mentioned *Acacia* spp., pomegranate, grape, rose, castor, *Polygonum,* mulberry, *Verbena, Magnolia,* potato, nightshade, *Bougainvillea, Amaranthus, Chenopodium,* quince, apple, peach, apricot, fig, walnut, willow, pepper, and *Casuarina.* This wide range of foodplants not only adds to the difficulty of control but increases the risk of its importation into new localities.

The appearance of this insect is shown in the two figures which are reproduced here (Plate XXXVIII) and which have been copied from the accounts given by French(3) and Essig(6). The adult female is about 5 mm. (⅕ inch) long and rather less in breadth and is of a lighter or darker brown, reddish or blackish colour, but the body itself is overlaid by a large, white, fluted, cottony mass, which may be half-an-inch in length, and in which the eggs are laid. On separating out this brilliant white cottony mass, the small cardinal-red eggs may be seen ; each egg is about 0·75 mm. in diameter and there may be four hundred to a thousand eggs in each cottony egg-sac. The females cluster in masses on the stems of their foodplants and are

then conspicuous objects, as will be seen in the figures. The male is a minute orange-red, winged insect, slightly over 3 mm. long and expanding only 7½ mm. across the wings; it appears to have been observed only rarely and it seems possible that the females may reproduce agamogenetically at times. Regular pairing occurs, however, when males are present and an account of the process has been given by Martelli(5) and more lately and fully by Shinji(36). Technical descriptions of the male are given by Riley as quoted by Brain(27) and of the female by Comstock(2) and Brain(27), and entomological readers may be referred to these publications. The non-entomological reader will doubtless be able to recognize the insect from the figures given here.

As regards control, this insect provides an excellent example of the way in which a pest may be controlled by intelligent use of its natural enemies. We have already seen how *Icerya purchasi* was introduced into America with dire results to the orange-groves. For many years mechanical means of control were tried against it but, all such having failed, in 1888 Professor C. V. Riley, then Chief of the American Bureau of Entomology, sent Mr. Albert Koebele to Australia to try and discover any insect which kept this Scale under control in its native land. In this Koebele was quite successful, for he found that in Australia *Icerya purchasi* was rendered comparatively harmless by a small red-and-black ladybird beetle known as *Novius cardinalis*. This ladybird was carried to California where it multiplied and flourished at the expense of *Icerya* until the latter became no longer a serious factor in the Citrus production of California. *Novius cardinalis* was introduced with equal success into Hawaii in 1890, into South Africa from California in 1891 and has since been introduced into Portugal, France, Italy, Malta, Scio, Syria, and Egypt, and it is understood that steps are being taken to secure its introduction into Ceylon.

Novius cardinalis preys on *Icerya purchasi*, both as an adult and as a larva. French gives an interesting account(3) and says that the larva of *Novius* "is pinkish and hairy and is very voracious, tearing as it does the *Icerya* to pieces as a dog would tear a piece of meat. They increase very rapidly and, when introduced into an

orchard where there is *Icerya*, they soon make themselves quite at home and devour the Scale in all directions. The beetle itself is also very partial to the *Icerya*, large or small it is all one to the *Vedalia* [*Novius*], who at once seizes it and kills it." French also * notes that the *Novius* "would, at least in the perfect state, appear to be somewhat fastidious as to its food. For example, some...... were tried by myself on a number of different kinds of Coccidæ, including *Eriococcus*, *Pulvinaria*, and other kinds unprotected by a shield-like covering; but......they would not tackle them, even after I had purposely kept them for some days without food, as an experiment to test their powers on Coccids other than *Icerya*." The fact that *Novius* exhibits this special predilection for *Icerya* is rather a special point and one which was overlooked later on by the Florida orange-growers, who, having heard of the success of *Novius* in checking *Icerya*, sent for some for trial against other Scales which were damaging their orange-groves; the *Novius* arrived in due course together with some *Icerya* as food on the journey and the beetles and their food were liberated in an orange-grove, where the beetles soon died off for want of food whilst the *Icerya* hatched out from the eggs left by the Scales and flourished to an extent which required a great deal of expenditure to bring under control. The damage done in this case was due to the want of expert advice and not to any failure on the part of *Novius*.

Besides *Novius*, *Icerya purchasi* is attacked in California by the hymenopterous enemy, *Ophelosia crawfordi*, and the dipterous parasite *Cryptochætum* (*Lestophonus*) *monophlebi*, Skuse, the latter constituting an important check, although it has not attained the notoriety of *Novius*. An account of this fly is given by Smith and Compere(32); see also Knab(18).

Although these natural enemies keep *Icerya* within bounds they do not exterminate it, and it would appear, by the reports of Entomologists in affected districts even where *Novius* has been introduced, that control by means of natural enemies requires to be supplemented at times by artificial methods, such as spraying. Mr. C. French (junior), for example, has lately recommended(34) spraying in Victoria, where he says that red oil, lime-sulphur and kerosene

emulsion sprays are used as controls. Should we in India be unfortunate enough to import *Icerya purchasi*, therefore, it is likely that considerable damage may be done and that such damage will only be mitigated, and not altogether removed, by the subsequent importation of the natural enemies of this pest.

So far as we know at present, India is free of this Scale. It is, however, quite possible that it may occur. If any readers should come across specimens answering to the description and figures here given, they will confer a benefit on the general public by informing me at once and sending specimens to Pusa for examination in order that prompt measures may be taken to prevent the spread of this noxious insect.

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CHEMICAL CONTROL IN CANE SUGAR FACTORIES : A REVIEW.*

BY

C. SOMERS TAYLOR, B A.,

Agricultural Chemist to the Government of Bihar and Orissa

IN his book on Cane Sugar and its Manufacture in Java Dr. Geerligs compressed into a very small space what he considered to be the main theoretical facts influencing the production of sugar in the great Dutch dependency. This book gave a very clear account of the ideas held by most sugar chemists at the time of writing, and indicated, on a broad basis, the lines upon which research both in cane breeding and in manufacture had been most successful in Java. The volume[1] under review is a systematic account, for the practical man, of the various processes, which should be carried out, in order to ensure that the best use is being made of the improved methods which have been ably described in the original book on Cane Sugar.

The necessity for chemical control in modern sugar factories is obvious. The whole manufacture, from the time the cane is cut until the raw sugar is sent out, depends upon intricate chemical processes, in which a slight variation in method may involve losses, which may make the modern factory, with its enormous outlay upon machinery and staff, very little more efficient than the old open pan method with its small initial outlay, and poor out-turn. It is to check such losses, and to find out their reason, that the presence of a skilled and well organized chemical staff is an absolute necessity in a modern sugar factory, and the book under review has

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1 *Chemical Control in Cane Sugar Factories* by H C. Prinsen Geerligs, Ph. D., Revised and Enlarged Edition, 140 pp. (London : Norman Rodger), 10s. net.

been compiled for the use of the head chemist of such a staff, giving him the details by which every process can be checked from the field to the sugar bag.

The book deals entirely with the chemical aspect of the manufacture and is divided into seven parts, each part dealing, systematically, with the various analytical processes and records that are necessary to keep a complete check upon the working of the factory.

Dr. Geerligs pays particular attention to the description of methods of accurate sampling. All workers on sugar are aware of the enormous differences existing from plant to plant in the sugarcane. Various methods have been devised to ensure the selection of an average sample, which shall yet be small enough to work with in the laboratory, and methods are laid down in this book which should produce such a sample. The scheme for field samples shown on pages 7 and 8 is of great interest, in view of the large losses that must ensue as a result of the cutting of unripe cane, from its low sucrose content, and low quotient of purity. Such a scheme would be difficult to carry out when cane is grown over an extended area of country as is generally the case in Bihar, but could easily be applied to lands under the immediate control of the sugar factory.

Finally on page 47, at the end of the first part, an excellent recapitulation is given of the necessary analyses to be done in a properly organized sugar factory.

The second part deals with the " Determination of Quantities " and shows how best to calculate the quantity of sugar actually obtained as compared with that brought into the factory in the uncrushed cane. On page 58 is given a very useful table, from which the sugar chemist can read off what proportion of the total sugar should be obtained for a given quotient of purity. From this table it would appear, for instance, that for a cane giving 60 per cent. of juice of 15 per cent. saccharose content, and a quotient of purity of 80, we might expect to recover some 8 per cent. sugar of 96° polarisation. A less percentage would indicate the possibility of some avoidable loss and a possible saving to the factory. It may, therefore, be taken

that a table of this kind, calculated from the formula given at the base of page 57 of Dr. Geerligs' book, should be in the hands of every chemist in charge of a sugar factory. This table is probably of more practical use than the one on page 60 which has been calculated from theoretical considerations and is not based, as is the former one, upon practical experience.

In short, it may be said that this part of the book deals with the continuous routine calculations which check the daily working of the manufacturing plant.

Part three is devoted to stock-taking and calculated percentages. It is a brief discussion of the various calculations to be made at stated periods, which will give an idea of the average efficiency of the factory during the whole run. There is a page on stock-taking and nine pages which are in the main a balancing, for a longer period, of the calculations previously used for the daily check.

Part four deals with several calculations which have not previously been mentioned, and also indicates the amount of assistance that will be requisite to carry out the work. A method for general supervision is indicated, by which it should be possible properly to ensure that the work is being carried out accurately. This method is that all juices and polariscope tubes shall be kept for a certain time, in order that the chemist may verify the results at any unexpected moment.

In part five a brief account of factory and laboratory instruments is given which indicates the main points of interest to be observed, while on pages 97 and 98 there is a very useful list of laboratory apparatus required.

The next part, the sixth, comprises two most useful tables, one for finding the sucrose content of juices from their Brix and polarisation, and the other for comparing Brix with the specific gravity and the percentage of solids contained at 17·5°C.

Finally, the last part of the book is taken up with models of books by means of which may be entered the records described in the previous sections, so as to check the work of the factory.

The whole volume, as Dr. Geerligs says, "presents the most modern methods that are in use for the sampling and analysing of

the several products, and the calculating and recording of the results in cane sugar factories, in almost every cane-growing country of the world." It has been arranged in such a way that it can be understood by all that have had anything to do with sugar. The methods are simple, and the processes can all be carried out by junior assistants under proper supervision, so as to produce results, from which when tabulated the head chemist may accurately control the whole work of the factory.

SOME EXPERIMENTS IN MANURING FOR DOUBLE CROPPING (*DO-FASLI*).*

BY

B. C. BURT B. Sc.,

Deputy Director of Agriculture, Central Circle, United Provinces, Cawnpore.

THE system of double cropping known as *do-fasli* in which a *kharif* (monsoon) crop is immediately followed by a *rabi* (cold weather) crop is common in the United Provinces, particularly in the canal-irrigated tracts but also in Oudh, and indeed in many parts of India. It is also not unknown in other tropical and sub-tropical countries where there are two marked seasons. In many cases the second crop, *e.g.*, peas following rice or cotton, is merely a catch crop. In such cases the rotation presents no feature of special interest and, as the catch crop is most often leguminous, is agriculturally sound, if the water supply is adequate and provided that (as unfortunately is sometimes the case) a main crop, such as wheat, does not suffer from the delay in irrigation due to anxiety to establish a catch crop.

In one well-known example however—wheat following maize—not only are two staple crops grown but both are cereals and make similar demands on the soil. Further, the wheat crop is perhaps the more important of the two. This rotation is not unknown in other maize-growing countries and presents certain features of general interest. It is perhaps most common in certain parts of Oudh and is not accompanied by the high cultivation characteristic of some other well-known instances of double cropping, *e.g.*, the famous

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maize-potato-tobacco rotation of Farrukhabad. Generally, however, manure is applied for the maize crop—usually cattle dung and village refuse. It is probable that high rents and the comparatively precarious character of the unirrigated maize crop have led to the adoption of this rotation.

It is clearly realized by cultivators that *as a rule* much larger yields of wheat are obtained from fields that have been cultivated fallow throughout the monsoon than from *do-fasli* fields. Two limiting factors are obvious, *viz.*, the difficulty of getting adequate cultivation after the removal of the maize to produce a fine seed-bed for the wheat, and lack of moisture for the young wheat particularly when the rains in September are scanty. These objections, however, do not always apply. Where ample irrigation is available from a tank or canal the seed-bed can be easily prepared after a preliminary watering and adequate moisture is ensured for germination and for the early stages of the wheat crop. The appearance of many cultivators' fields would suggest that the wheat crop suffered from lack of available nitrogen and it appeared at first sight that there might exist here one of the few instances where artificial or other quick-acting nitrogenous manures might find a profitable use. This view was apparently confirmed by some preliminary results obtained from a field of wheat following maize where an application of 1½ cwt. of sodium nitrate per acre gave the record yield of 38 maunds (50 bushels) of wheat per acre. The maize had been preceded by sugarcane but the appearance of the wheat crop in its early stages suggested that it would benefit by a top-dressing of nitrate. A series of experiments was therefore started to try and obtain more definite information on this point.

The field referred to above was divided into four uniform plots and maize followed by wheat was grown for two years, no manure being applied to the maize crop and sodium nitrate applied at 1½ cwt. per acre to the wheat crop as a top-dressing in two of the plots only. In 1916-17 cattle manure at the rate of 10 tons per acre was given for the maize crop and ammonium sulphate and castor cake added to the manures used for wheat—these were applied before sowing, nitrate as a top-dressing as in

previous years. The yields of wheat are shown in the following table :—

Yields of wheat in lb. per acre.

Treatment	1914-15	1915-16	1916-17 (maize manured)
Wheat manured with sodium nitrate.	{ 1,710 1,840	1,980 { Av 1,910 { 1945 }	2,000
No artificial manure	{ 1,910 2,200	1,860 { Av 1,570 { 1715 }	2,110
Wheat manured with ammonium sulphate .			2,240
Wheat manured with castor cake .			2,200

Sodium nitrate was applied at 1½ cwt per acre, other manure at the equivalent rate to furnish the same amount of nitrogen

In all three years the maize was sown with irrigation by the end of May and the land ploughed, after harvesting maize, by the middle of August. This permitted ample cultivation for the wheat crop and represents the rotation under optimum conditions. In the first year the wheat plots receiving nitrate of soda were badly lodged by wet weather in February. In the succeeding year, with the field waning in general fertility as the effect of the manure applied for sugarcane in 1912 disappeared, and with a good wheat season the effect of nitrates is distinct though barely profitable. In 1916-17 the results are very much what would have been expected. The application of nitrate to a soil containing ample nitrogenous matter (and thoroughly cultivated between the two crops) resulted in a small diminution of yield. The use of castor cake and ammonium sulphate by supplying more readily nitrifiable material caused a slight, though unprofitable, increase.

A further series of experiments was started in 1916 to ascertain the effect of the time of removal of the maize on the wheat yields. For this it was necessary to use the plots used for the old standard maize experiments which were discontinued in 1913. These had since been cropped uniformly without manure as follows : 1913-14 wheat ; 1914-15 American cotton ; 1915-16 wheat. The yields of wheat in 1915-16 varied from 1,452 to 2,396 lb. per acre,

eight plots yielding over 2,100 lb. per acre. Plots were carefully paired according to their wheat yields and previous history and three sets of sowings were made in May and June, the corresponding dates on which it was possible to plough the plots after harvesting the maize being August 28th, September 8th, and September 16th, respectively. The results are shown in the following table :—

Yields of wheat in lb. per acre.

1ST SERIES.

Ploughed after maize on August 28th.

Maize manured with castor cake		Maize unmanured	
Wheat manured with sodium nitrate	1,972(c)	Wheat manured with castor cake ..	2,323(a) 1,609(b)
Wheat manured with $(Nit)_2 SO_4$ ..	1,657(c)	Wheat unmanured	1,718(a)
Wheat unmanured	1,572(c)		

(a) These plots received organic manure annually until 1912.

(b) This plot received organic manure annually until 1908.

(c) These are strictly comparable amongst themselves but not with (a) and (b).

2ND SERIES.

Ploughed after maize on September 11th.

Manured with castor cake for maize		Maize unmanured	
Wheat manured with sodium nitrate ..	1,597	Wheat manured with sodium nitrate ..	1,779
Wheat manured with sodium nitrate ..	1,597	Wheat manured with sodium nitrate ..	1,779
Wheat manured with ammonium sulphate	1,403	Wheat manured with castor cake ..	1,246
Wheat unmanured	931	Wheat unmanured ..	1,113

3RD SERIES.

Ploughed after maize, September, 1916.

Manured with castor cake for maize	
Wheat manured with sodium nitrate	1,029
Wheat unmanured	823 1,004

All wheat plots were sown at the same time, *viz.*, October 30th.

The diminishing yields of wheat, as the period available for cultivation (after removal of the maize) is lessened, are striking. It will also be seen that in nearly all cases the use of sodium nitrate has given materially enhanced yields. Only in the case of the first sowing has castor cake given good results.

Wheat after Juar.

Juar (*Andropogon Sorghum*) is generally believed to be a more exhausting *kharif* crop than maize, and the marked effect which a dressing of sodium nitrate produced on a fodder crop of oats, grown after *juar* in 1914-15, suggested that some further information might be obtained by growing wheat after *juar* with and without nitrogenous manures. Wheat was sown after fodder *juar*, for which the land had previously been well manured with cattle dung and, with the object of ascertaining whether the nitrogen supply was the only factor of importance, the experiment was pushed to the extreme limit and a crop of early ripening wheat (Pusa 4) was grown after *juar* which had been allowed to mature seed in the usual way. In the latter case the *juar* was not harvested until the end of November, it being just possible to get the land ready and to sow wheat by the end of the first week of December. The results of two years' experiments are shown in the following tables:—

A. Wheat after fodder Juar. Yields in lb. per acre.

	1915-16 Fodder *juar* removed Sept 2nd Pusa 4 wheat sown Nov 17th	1916-17 Fodder *juar* removed Sept 9th Pusa 12 wheat sown Oct 10th	1916-17 Fodder *juar* removed Sept 28th Pusa 4 wheat sown Nov 11th
Wheat manured with sodium nitrate	1,922	1,552	1,869
Wheat manured with castor cake	2,306	1,880	2,056
Wheat unmanured	2,184	1,512	1,887
Wheat manured with ammonium sulphate		1,384	.

B. Wheat after Juar allowed to mature grain. Yields in lb. per acre.

	1915-16 *Juar* harvested Nov 18th Pusa 4 wheat sown Dec 5th	1916-17 *Juar* harvested Nov 28th. Pusa 4 wheat sown Dec 3rd. A	B.
Wheat manured with sodium nitrate ..	1,296	1,136	1,440
Wheat manured with ammonium sulphate		976	1024
Wheat manured with castor cake ..	702	848	944
Wheat unmanured	558	288	624

The results obtained with wheat after *juar* clearly show that we are dealing with a nitrogen problem entirely; the use of canal water enabled questions of cultivation (so far as the preparation of a seed-bed was concerned) and moisture supply to be eliminated. The explanation of the results appears to be fairly simple. Given an adequate supply of organic matter in the soil, the limiting factor is the time between the removal of the *kharif* crop and the sowing of the wheat crop. Nitrification is active at the close of the monsoon provided that the field is in suitable condition but rapidly slows down with falling temperatures. If the field is poor in organic matter, or if the *kharif* crop is removed too late, the supply of available nitrogen for the succeeding wheat crop is reduced, and this is shown at once in the yields from unmanured wheat plots, while in these circumstances quick-acting manures have considerable effect.

In the *do-fasli* maize-wheat rotation early planting of the maize or the use of early maturing varieties together with an adequate general manuring of the maize crop is sufficient to produce normal wheat yields. It is clear that nitrates might be used with effect to partly neutralise the effect of inadequate general manuring or insufficient cultivation between the two crops. How far this would be profitable is doubtful, and, in view of the prejudicial effect of nitrates on the texture of certain soils, one would be chary of recommending its general adoption. Ammonium sulphate has, on the whole, been disappointing. Castor cake (or a similar oil cake) while not producing the same marked effect in extreme cases is probably more suitable for general use, the benefit being less transitory.

The somewhat unexpected results obtained with wheat after fodder *juar* may be of economic importance. If, in a canal-irrigated tract, it is possible to take a heavy crop of fodder *juar* followed by a normal crop of wheat it would materially assist to solve the fodder problem. One of the reasons why silos have not come into more general use is the difficulty in collecting sufficient fodder within a reasonable time to fill even a small silo, whilst few cultivators are able to set aside considerable areas of land for growing fodder crops

for ensilage. If fodder *juar* can be so grown without diminishing the area available for wheat (or barley) the difficulty is partly solved.

It is realized that the above results are open to a certain amount of criticism on the score of lack of duplication. But the experiments were carried out on fields of known history and the general conclusions appear to be justified.

THE ALLOWANCE FOR DRIAGE OF CROPS IN SETTLEMENT OPERATIONS.*

BY

S. GRANTHAM, B.A., I.C.S.,

Settlement Officer, Myaungmya, Burma

A SHORT paper by Mr. Evans, in the *Agricultural Journal of India* for April 1917, on Driage deals chiefly with paddy, groundnuts, and *juar* (*Andropogon Sorghum*) and in a shorter way with some *rabi* (spring) crops. Mr. Evans believes that this matter of driage has not received due attention in crop experiments and remarks specially upon its importance to Revenue Authorities. Some account of recent enquiries on this head in Burma in connection with revenue settlements may be of interest.

One of the sources of information as to the out-turn of the crops in the area of settlement operations is a group of experiments in each of which a measured area is reaped at the time when local opinion considers it fit for reaping, the yield being then threshed or otherwise treated according to custom and measured. As the real object of the experiment is to estimate how much is obtained by the cultivator for selling his crop, it would be proper to follow exactly the process from reaping to marketing which is practised by the cultivator.

But for some crops, for example, paddy in Lower Burma, the number of experiments in any year made in one settlement area, being necessarily increased as much as possible to give the widest basis for the assumption of a standard out-turn, may approximate to 2,000 and be distributed over a cultivated area of six or eight hundred square miles in which distances may be enhanced by the

* Received for publication on 23rd June, 1917.

inclusion of an equal area of jungle; and all these experiments may have to be conducted in a single month. It is obviously not possible to furnish reliable agents to reap and measure the crop and to watch it continuously from beginning to end of these operations if the cultivators' process is followed precisely; sixty to eighty trained reaping clerks and supervisors are generally employed and they must measure the crop as soon as possible when it has been reaped. The usual practice is to reap sample areas of one-half to three-quarters of an acre each and to thresh completely, measure the paddy and allow for driage what the Settlement Officer thinks proper, ten per cent. being the usual amount. In recent years there has been dissatisfaction in the minds of some officers on this point. Accordingly Mr. C. F. Grant, I.C.S., made the following record in his report on settlement operations in a part of the Pegu District of Lower Burma which was published in 1914:

"Rice in the husk stored in bags and kept under cover for two months was found to have shrunk about 5 per cent. in bulk, a result which agrees with similar experiments in other (Settlement) Parties. In the Nyaunglebin Sub-Division the crops are cut and the sheaves are left lying unbound in the fields for a period which ranges from one to three weeks. It is during that time, when the plant is dead, that most of the shrinkage takes place. To fix approximately the amount of shrinkage during this period of exposure to the sun, two Assistant Settlement Officers in the end of December selected and immediately threshed out the crop on fields adjoining completed selections. These fields were as far as possible exactly similar to the selections they adjoined, and crops on them had been reaped by the owner and left lying on the ground in the ordinary way. They yielded less than the ordinary selections sometimes by as much as 10 per cent., but it was not possible to draw any very positive conclusions, as the experiments were necessarily not very numerous. Mr. Stewart and I carried out a number of experiments with newly threshed paddy, treating it in the same way as the people treat their paddy if they wish to use newly garnered grain

for immediate consumption. The grain is spread out on mats and exposed to the sun for three days. We both got a shrinkage of 25 per cent. of bulk and in one instance even that figure was exceeded. That degree of dryness is not reached by the grain that is sold to traders, and there is probably very little shrinkage in it after the sheaves reach the threshing floor. A reduction of 12·5 per cent. or two annas in the rupee was made for the driage. It is not excessive considering the way harvesting is carried on in the settlement area."

Mr. Grant's report had not yet come to my notice when I began to make observations on driage for the purposes of the settlement of the Prome District. The method which I adopted was to take from each field selected for reaping the first basketful (nine gallons) of paddy threshed. Usually this was ready at about 8 A.M. It was spread out, after weighing, on bamboo mats so thinly that every grain was exposed to the sun, and, of course, it was carefully watched to prevent loss by birds, animals, children, wind, etc. At intervals of an hour or so the paddy was gathered up on the mats and re-spread. After three or four hours when all the other paddy had been threshed the drying sample was again measured and weighed. The shrinkage occurring in this first drying naturally depends upon many circumstances which affect the humidity of the grain at the time of reaping. Some of these are the soil, the kind of paddy and its degree of ripeness, the weather for the last few days as well as at the time of reaping, and the method of harvesting. It is evident, for instance, that paddy reaped on a wet misty morning or after heavy dew will be bulky and heavy. The shrinkage in several hundred of these experiments varied from a mere trifle to one-fifth of the original bulk and averaged about one-tenth to one-eleventh of that. This stage of the experiment had been carried out in previous settlements and generally the results obtained had been held to show that an allowance of 10 per cent. by measure was well on the safe side, and 6 per cent. had been suggested as about the correct figure.

But in Prome the observations were carried a stage further by taking twelve samples, each about 7½ to 8 gallons, of the paddy so dried on the mats, sewing them up in bags, storing carefully, and

weighing once a week. All the samples save one were of the variety known as *emata* which is the dominant variety of the district and is almost peculiar to it; this variety is known to the Gujarati merchants in Rangoon who export it as *sukundi* on account of the aroma which certain of its sub-varieties possess. The samples which nearly all belonged to different sub-varieties were taken from various parts of the district and a record was kept of the conditions at reaping time, soil, and all other particulars which seemed likely to affect the grain. It may be noted too that the seasonal conditions vary greatly in Prome District even at short distances, so that of two places thirty miles apart one may have a bumper season and the other almost a failure.* It was found, however, that the shrinkage was equal and uniform in all the samples whether they came from open plains or narrow ravines, from wet clay soil or a high sandy plateau or boss, with the one exception that in one township, both on clay and on sandy soil, the loss in the first month was one per cent. of the original bulk larger than elsewhere although it was normal after that. The reapings all took place about Christmas time, and the normal shrinkage was found to be two-fifths per cent. per week by weight until the beginning of April after which there was no further shrinkage until the 13th May when the experiment was stopped; at that time the volumes were measured and found to have diminished by a regular proportion of approximately $7\frac{1}{2}$ per cent. as compared with the $5\frac{1}{2}$ per cent. lost in weight. Thus the total loss in bulk varied from about 8 to about 28 per cent. by the middle of May. For settlement purposes a uniform reduction of $12\frac{1}{2}$ per cent. was applied to the measure of the freshly-threshed grain, the usual selling time being from the end of January to the beginning of March.

When a large number of observations of the out-turn are made in any one tract, as in some settlement operations, the average of the results of Stage I may give a satisfactory basis for estimating the reduction due to driage which should be made from the measure of

* The total annual rainfall averaged for the period 1901-15 appears to vary a little above or below 50 inches in different parts of the district; the difficulty arises from untimely intervals of dry weather.

freshly-threshed grain when the harvesting is conducted in a fairly uniform manner. But the variability of the results in Stage I in Prome renders it improbable that a uniform reduction for driage can be determined, which could be satisfactorily applied to the measure of the freshly-threshed grain in a *few* experiments to give a result sufficiently accurate for any purpose connected with a settlement or a crop forecast. Further, the variations required for locality and weather conditions, the kind and condition of the paddy, would be so wide that a complex table of factors would be necessary. But the uniformity of the results in Stage II of the Prome experiments points to a way out of the difficulty as it shows that the process of Stage I brings the grain to an approximately uniform degree of dryness. By removing the external dampness and drying the outer layers the variable part of the correction required as a result of weather conditions and the condition of the paddy is apparently accounted for. It appears therefore that a simple yet valid system could be evolved if the dryness of paddy which has been exposed to the sun in the manner of Stage I were compared with the dryness at selling time of exactly similar paddy which is threshed and garnered in the ordinary way followed by the cultivator. It may be noted that Mr. Evans' figures also show a rapid reduction of weight in the first three hours (except for the very ripe paddy of Experiment IV) followed by a slower and retarded reduction in the next three days. It is quite possible that three days of such an intensive drying process will make the paddy drier than it is normally when it is sold; and in any case the District Officer cannot be asked to return to the village after three days to complete the experiment. Also no improvement in accuracy can be obtained by leaving a three days' drying process and the final measuring in the hands of subordinates of a grade low enough to be able to give that time; the experiment is not reliable if the grain is not watched by a responsible officer all the time it is exposed to the sun. It seems however that all that need be asked of District Officers is that a quantity of paddy large enough to be a satisfactory subject of observation should be taken as soon as it is ready and dried for a definite period, say four hours, in the manner of Stage I and the loss in weight and bulk in

this process recorded. (The total recorded out-turn of the reaped area will include the measure of this dried paddy before the drying.) The central office can then estimate the bulk and weight of the whole out-turn after four hours of such drying and apply such further correction as may be needed to show the corresponding amount of grain which would normally be found at the time of selling. This last correction would be comparatively small and it would be uniform over considerable areas and for large groups of varieties—possibly a sufficiently accurate figure for uniform application over a whole Province could be fixed ; the experiments needed for its determination can easily be devised but they ought to be repeated at intervals of a few years.

It may be noted that in Prome the paddy put into bags was measured with repetitions of a small measure of about half a gallon so as to average out the small variations inevitably occurring in the measurement of grain by bulk, and the paddy was piled into this slowly by hand and then its surface swept with a strikle. In measuring the large bulk of the undried paddy the grain was poured into the measures in a single action as is usually done when paddy is measured for selling.

Other Crops than Paddy.—Experiments were also made in Prome with other crops.

For **groundnuts** five plots totalling 1·12 acres were reaped about New Year's Day 1916 and yielded 689 viss* weight of nuts, which, after being dried in the sun for three days just as is customary with the cultivators, gave 530 viss in marketing condition—a loss of 23 per cent. by weight. An experiment with 18 pounds of fresh nuts showed that eight days' drying reduced the weight by 29 per cent., after which there was no further appreciable loss. These groundnuts were grown on a soil consisting, apart from organic matter, almost entirely of sand, and there had been no rain for two months save a heavy downpour on one day at the beginning of December which registered 4·1 inches.

* A "viss" is 3·6 lb.

For mayin or hot weather paddy the loss by driage on the mat was, according to my memory, about one-twelfth, but I no longer have the recorded figures available.

For **tobacco** 356,000 leaves were cured in the sun under the supervision of a member of the settlement staff in the manner usually followed by the cultivators, and a sample of 55 pounds weight was taken to observe the change in weight which took place between the curing time (April and early May) and the selling time (early August). At this season the cultivators keep the tobacco in their houses in large stacks measuring about five feet each way, where it slowly ferments; if it gets too hot they take off the leaves, bundle by bundle, from the stack and repack in a new stack. The change in the tobacco is not of course the same as that in paddy which is standing in a heap, but it gives rise to a similar need for correction in observations of out-turns. My sample of 55 pounds of well-cured tobacco was packed in a block similar to those in the cultivators' houses but, of course, much smaller. A cover of open-woven gunny was sewn round it to prevent loss and the whole kept in a wooden box which was opened all day in my room but closed at night to prevent tampering; this also helped to make the conditions more nearly the same as in a large stack. The bale was weighed on the 31st May when it was first ready, on the 6th August when sales were beginning, and at intervals afterwards with the results shown in the margin. It was decided therefore to reduce the weights observed in the experiments in May for cured leaves by one-sixth, to determine the weight which the cultivator obtains for sale in August.

Date	Weight	Loss per cent
May 31 ..	55·00	
August 6 ..	46·25	16
August 21 ..	45·25	18
September 6 ..	44·75	19

In conclusion I must express my regret that only three or four days before Mr. Evans' paper came to my notice the detailed records of all the experiments in Prome to which reference has been made above were destroyed on the receipt of a copy of my report in which the results were summarised; the figures now given are quoted from the summaries in that report.

THE PROBLEM OF SUGAR MANUFACTURE IN INDIA.

BY

WYNNE SAYER, B.A.,

Assistant to the Agricultural Adviser to the Government of India.

IN these days when every effort is being made to make the British Empire self-supporting the question whether the Empire cannot in future do without the beet-sugar grown by the enemy countries is engaging much attention. It has recently gone the round of the daily press that the Home Government are out to encourage the cultivation of sugar beet in the United Kingdom, and that in Jamaica and the West Indies the question of State-aided central sugar factories is being satisfactorily dealt with. It is understood that there is much room for the development of the sugarcane crop in several British Colonies, and there is every reason to hope that with more intensive cultivation the output will be considerably increased. The sum total of the actual or possible acreage available in the British Colonies is nearly 3 million acres (2,946,675) capable of yielding 4,775,000 tons of sugar.* It can also be safely assumed that sugar will not sink to its pre-war level of prices in the near future as the *per capita* consumption of sugar is increasing almost in all countries, the beet-growing area has suffered severely from this war, and there is no prospect of any immediate great expansion of sugarcane cultivation in the tropics except in Cuba. Cuba has increased her output of sugar from 300,000 tons to 3,000,000 tons during the last twenty years, and it is believed that

* See the Table on p. 6 in "The High Price of Sugar and How to Reduce it," by Harold Hamel Smith.

there are still large areas of rich land at present unworked which may be utilized for sugar with the American capital and machinery pouring into that country. But since the world's pre-war consumption of sugar was 18 million tons, cane sugar supplying 9 millions and beet-sugar an equal amount, and as the beet-growing area has suffered enormously and will most probably be prohibited from dumping the markets of the British Empire, any increase in the Cuban output will not materially ease the situation. It is held in some quarters that if India alone improves her output, her present acreage of 2,437,000 under cane (with about 175,000 acres under sugar-yielding palms, etc.), will not only enable her to meet her own requirements of both raw and refined sugar and thereby set free the quantity of sugar at present imported, but also to export her surplus produce. It is pointed out in this connection that the imports of over 800,000 tons of refined sugar into India in normal times cannot be supplied by the British Empire without creating a deficiency of supply elsewhere, since the total output of the British Colonies, excluding the home consumption at the producing centres, is only about 880,000 tons. It is to be noted, however, that notwithstanding the high price of sugar due to the war, there has been no increase in the cane cultivation in this country. On the contrary, if we take the statistics of the last twenty-five years, we find that while in 1892 the area under sugarcane was 2,798,637 acres[1] there is now a decline of some 350,000 acres as will be seen from the forecast for the sugarcane crop of 1916-17 which gives 2,414,000 acres[2] (to which must be added about 23,000 acres from unreported areas where the cane is grown on a very small scale). The industry has declined most conspicuously in Bengal including East Bengal (497,000 acres in 1916-17 against 1,071,200 acres in 1892-93) and also to some extent in the Central Provinces. During the same period the imports of cane and beet-sugar (both refined and unrefined) rose from roughly 100,000 tons to over 800,000 tons in 1913-14, and yet the area under

[1] See p. 27 of "Notes on Sugar in India," by Frederick Noel-Paton, 3rd Edition, Calcutta, Superintendent, Government Printing, India.

[2] Since this was written the first sugarcane forecast for 1917-18 has been issued. It shows an increase of 9 per cent. over the acreage for the previous year.

cane in India is steadily growing less. During the last three years of the war, when the imports of foreign sugar shrank from 800,000 tons to 440,230 tons, the area under cane should have expanded proportionately, had refined sugar been a necessity and not a luxury to the majority of the consumers in India, and if a fairly good number of sugar factories installed on modern principles had already been working in the country. The plain facts are that there are few[1] factories manufacturing sugar direct from cane or refining it from palm jaggery or *gur*, and further, even if there had been a desire evinced to open new factories, the serious shortage of tonnage and the difficulties in the way of getting new machinery from abroad were sufficient to make the most enterprising capitalist shy off.

Now what are the peculiar difficulties that the white sugar industry has to contend with in India? Some place in the forefront the class of canes grown in India and point out that in Northern India, where nearly 90 per cent. of the sugarcane is grown, thin, hard, fibrous varieties generally unsuitable for the economical production of sugar preponderate. It is true that canes in Northern India only contain 9 to 11 per cent. of sucrose (varying with the season)[2] while in Java and other sugar-producing countries it is 12 to 13 per cent. and even more. It is also true that the yield per acre is about 40 tons in Java; while in the best sugar-growing tracts of the United Provinces the average is about 20, and that elsewhere in Northern India, except the Punjab, it is about 15 tons. But it should be noted that the estimated net cost of cane production in the field, without cutting and carting charges, comes to Rs. 4 to Rs. 5-3 per ton in Java which is not lower than in certain parts of Bihar and Gorakhpur. This is because the cost of manuring cane is Rs. 35 per acre in Java[3] and also because the rents there run considerably higher than in the United Provinces. It is

[1] The Director of Statistics with the Government of India informs us that, according to the returns received in his Department, the number of sugar factories working in India in 1916 was 28. The annual output of these factories it is difficult to know. Roughly it must be about 100,000 tons.

[2] Clarke, G., *Agricultural Journal of India*, vol. VIII, p. 235.

[3] See p. 123 of "The World's Cane Sugar Industry: Past and Present," by H. C. Prinsen Geerligs.

true that Java requires only 10 tons of cane for a ton of sugar, while factories in India require about 13·8 tons,* but against this must be placed the ocean freight and import duty that Java sugar has to pay. While we do not deny that the 'problem of producing white sugar in India and competing with other countries will be much easier to solve if (1) the out-turn of sugar per unit area is increased by improving and intensifying the cultivation, and (2) if better varieties are selected with reference both to their actual sucrose content and their workability in the factory,' we maintain that great cheapness of raw material is not the sole or chief cause of Java's dominating the Indian market. **It is the profitable utilization of the whole of the available produce of the cane by means of factories equipped with the most efficient machinery that gives Java her advantage.** In this connection we quote the following from Dr. Geerligs' book[1] :—

"The manufacture of sugar from sugarcane in Java has attained to great perfection and may serve as an example of a well-managed and well-controlled business. The ample investment of funds in the newest machinery, the activity of the sugar experiment stations, the adequate training of sugar chemists and factory chiefs—all these have contributed towards making the Java sugar industry a model one of which it may rightly be proud."

Another difficulty pointed out is the existence of the *gur* industry on account of which the relative profitableness of the conversion of cane juice into *gur* and sugar has to be considered in each tract before any decision can be reached as to the possibility of founding a factory there. Sugar is not an essential food of the majority of the people, who prefer jaggery or *gur*. The *gur* being peculiar to India, its price is unaffected by the fluctuations in the world's sugar markets. It is true that in Java practically the whole of the cane crop is devoted to sugar-making while in India the great bulk is made into *gur* for eating purposes. Now if the producer utilized his produce to the full in *gur*-making and made more profit in this way than by selling the cane to a sugar manufacturer, there would be no reason to complain. But unfortunately it is not so. The wastage in

* See note at foot of table on p. 557 *infra*.

[1] *Loc. cit.*, p. 131.

cane-crushing and *gur*-making as carried on by cultivators is enormous; and if this loss is prevented and a slight increase in the yield of cane per acre brought about India will be more than independent of foreign sugar. It must also be borne in mind that the taste for sugar is growing as the annually expanding imports of sugar before the outbreak of war showed, while the demand for *gur* is almost stationary or not likely to expand in the same proportion. The abandonment, as the result of foreign competition, of refineries working with old indigenous methods has also added to the amount of cane available for *gur* production. To prevent the *gur* market being glutted and the profits from cane growing being further reduced, it is desirable, nay essential, in the interest of the cultivators themselves to divert a portion of the crop to sugar-making.[1] There are well defined tracts where factories manufacturing white sugar direct from the cane would be a boon to the cultivators. But where the manufacture of *gur* pays better on account of the superior quality of the product and the high price it commands it comes seriously in the way of white sugar-making by modern factory methods which require large capital and the assistance of many growers. It will obviously not pay to start sugar factories in such areas.

Minute sub-division of the land is also considered a great hindrance in the way of sugar factories in India. For commercial success the factories should naturally be as large as possible. A large block of land is consequently needed, so compact as to reduce the heavy carting charges to a minimum, and the factory should have control over the fields so that it may be kept constantly and evenly supplied with cane. In the settled parts of this country the holdings are small and such sugarcane as is grown is in scattered plots of small size. We, however, venture to think that these difficulties have been exaggerated. The cultivator, so far from being wedded to *gur*-making, is quite ready to abandon it if he is sure of a good price and a regular market for his cane at the factory. What he usually requires is an advance of some money which the factory owner should try to

[1] See the article on "The Sugar Industry in the United Provinces," by H. R. C. Hailey, *Report of the Ninth Indian Industrial Conference*, 1913.

arrange for as it tends to assist both ryot and factory. In Bihar no difficulty has been found in getting cane, in fact the cultivators prefer to sell their cane and offer more than the factory can work up. It may be argued that this state of things exists in Bihar because the European planter has farmed here for many years, and the people have become accustomed to work with him and grow crops for his factories, hence the planter has a certain amount of control over the crops grown and not infrequently a certain amount of land is attached to the factory which forms a basis for cultivation. But if this is so in Bihar, even in parts of the United Provinces Mr. Hailey thinks there is no reason to regard the difficulties in connection with the supply of cane as insurmountable.[1]

The fourth obstacle is held to be the competition of crops like paddy, jute, and cotton. Now Madras is capable of growing as good a cane as any place in the tropics, but as the area here is dependent upon irrigation facilities, the crop comes into competition with paddy which is the easiest to grow while sugarcane is one of the most laborious and difficult. With paddy at present prices and the possibility of growing another crop after it in the year, it is not likely that sugarcane will, even under favourable circumstances, replace it to any large extent. In Bombay, however, there is no such competition and splendid crops of cane are grown on the canal tracts in the Deccan. The Godavari and Pravara canals and the Nira Right Bank canal when completed will bring about 20,000 acres of new land under cane. In the Central Provinces also, the irrigational developments that are taking place will make considerable areas available for sugarcane growing. But in both these Provinces it will pay better to manufacture *gur*. In Bengal, low-lying land unsuited for cane is devoted to paddy while the higher land with sufficient water to do without irrigation is fully occupied by jute. Here there is room for considerable improvement both in the direction of cane and palm sugar, but there are difficulties as the Province is exposed to the full force of foreign sugar competition on account of its proximity to

[1] *Loc. cit.*, p. 60.

the sea. In Lower Assam there are large unoccupied areas on both sides of the Brahmaputra which can be utilized for sugarcane growing. There are special difficulties in the way such as control of surface water, absence of communications, and scarcity of labour which has to be introduced. But these difficulties can be overcome as has been proved at the Government Sugarcane Experiment Station in Kamrup where heavy crops of cane have been successfully grown. Assam thus offers a good field for large sugar factories. In the United Provinces and Bihar where poppy cultivation has been given up more land will be put under cane if the relative profitableness of the cane crop is proved to the ryot. In the Punjab[1] the climate is unsuitable and very poor yields of cane (10 tons per acre) are obtained. In the canal tracts cotton is a serious rival. In the North-West Frontier Province which has 32,000 acres under cane, the district of Peshawar alone commands 24,000 acres and this area is capable of being doubled as the result of the Upper Swat River Canal. Here the growth of beet has been found to be fairly satisfactory.[2] In addition this district, being far removed from the sea, has some sort of natural protection. A factory, if started here, would be able to work for a sufficiently long season (nearly six months). Burma also offers a prospective field for the fairly extensive cultivation of cane in the Mon canal area.

What then is the principal factor responsible for the moribund state of the Indian sugar industry ? The reader will have grasped that the most urgent reform required is on the manufacturing side. To indicate the grossly inefficient methods used in the recovery of sugar from cane in India, we give the following table.[3] The figures have been worked out on the assumption that cane is available at Rs. 7 per ton, a working price in North India.

[1] Even in this Province the official forecast for the year 1917-18 shows an increase of 24 per cent.. over the area reported last year. No doubt high prices of *gur* are responsible for this increase.

[2] See "Annual Report of the Peshawar Agricultural Station at Tarnab" for the year ending 30th June, 1915.

[3] See p. 15 of the "Note on Indian Sugar Industry and Modern Methods of Sugar Manufacture." *Bulletin No. 60 of the Department of Agriculture, Bombay.*

Process	Tons of cane to a ton of sugar	Cost of cane per ton of sugar	Net manufacturing expenses	Total net cost per ton of sugar
		Rs.	Rs.	Rs.
Khandsari	27·3	191	70	261
Hadi	20·2	141	56	197
Gur refining	17·4	122	60	182
Small vacuum pan ...	15·0	105	89	194
Modern factory (crushing 300 tons of cane per day of the type installed in Northern India)	13·8*	95	55†	150

* When the crop is poor, with low sucrose content and also low purity, as much as 16 tons of cane are required for a ton of sugar. But when good quality crop is obtained as the result of a favourable season about 12 tons of cane only are required.

† The manufacturing expenses are capable of further reduction.—[W. S.]

This table also shows that we can manufacture sugar at a sufficiently low cost in India to compete with foreign sugar if up-to-date factories are set up and a sufficient supply of cane is available at a reasonable rate. As a matter of fact the factory at Pilibhit and the sugar factories in Bihar were running successfully even before the war. As a modern factory requires only half the quantity of cane required by a Khandsari for the manufacture of a ton of sugar, it is obvious that the former can afford to pay better rates than the latter. The introduction of these factories with proper organization and efficient management will therefore be a boon in those parts where sugar manufacture is relatively more profitable than *gur*-making. At present we import 61 lakhs of rupees worth of molasses—the by-product of sugar factories—and large quantities of molassecuite which is a cattle food prepared from molasses. If more sugar factories are opened in India they will be able to meet this demand and a license to manufacture rum will not be essential if steps are taken to further develop the use of these by-products within the country itself.

It is necessary to ascertain the number and locality of suitable sites available for modern sugar factories in India. Mr. Noel-Paton[1] has given a list showing total area, area under sugarcane, neighbouring large towns, population, etc., of each district in India. This information requires to be supplemented in the

[1] See the chapter on "Openings for the Industry" in his "Notes on Sugar in India."

following way. A list of places where cane cultivation occupies in any single year about 3,000 acres within a radius of 5 miles or at such distance as can be commanded within 48 hours of harvesting should be prepared for the guidance of those who wish to set up central sugar factories capable of crushing at least 300 tons of cane a day. For this a special Government enquiry is absolutely necessary. Unless we can get and place reliable figures regarding the acreage under cane available in any locality or place, no capitalist will be attracted to the industry. What is therefore required is encouragement on the part of Government for capitalists to come forward. How did the Japanese Government promote the sugar industry in Formosa? We are not admirers of Japanese methods in that island, but the effective measures they took for creating a sugar industry on modern lines are pretty instructive. Why not institute a Government department giving facilities to sugar companies for the erection of modern factories and at the same time multiply sugar experiment stations for testing and introducing better varieties of cane and improvements in cultivation? If we adopt a vigorous policy of encouraging the formation of sugar companies, by subscribing for some shares or guaranteeing interest for a certain number of years, and provide a body of highly qualified officers who would go round and instruct the factory managers regarding the best type of machinery to be installed, the chemical control of the factories, the most profitable utilization of the by-products, checking waste, etc., we shall soon see a large number of factories springing up in India and a healthy industry in progress. Perhaps the question may be raised how Government is to meet the cost. We suggest that for the next ten years the import duty on sugar should be raised to 15 per cent. for Mauritius and other British Colonies, 20 per cent. for Java and other allied or neutral countries, and 25 per cent. for Germany and Austria. The proceeds will be over a crore of rupees and some portion of this money can be legitimately used for the fostering of the Indian white sugar industry.

Let us for a moment consider what it will mean to India if she comes into line with other sugar producing countries by the adoption

of improved up-to-date methods. Over 12 crores of rupees would remain in the country, cane cultivation would become more profitable and thereby make the cultivators more responsive to new ideas such as the trial of improved varieties, heavier applications of manure, and better tillage. The basis of Indian agriculture would be widened and firmly established by the rehabilitation of one of her staples. Her general economic condition would be materially improved by the substitution of a substantial and sound industry for a steadily declining one.

We now turn to the question of the *gur* industry. Even here there is great room for improvement. To those who know how many industries in the world now carry on solely by the successful utilization of by-products and careful economizing at all points, it is heart-rending to see the waste that is going on in this particular industry in India. The cultivator works hard for periods varying from 10 to 18 months, sinks a lot of capital (having regard to his means), raises a successful crop with the limitations under which he has to work, *e.g.*, imperfect implements, inadequate supply of manure, etc., and yet because he does not know or because he has no means he fails to recover even a decent average amount of sugar from his crop, in fact reduces the possible output by 35 to 50 per cent. and suffers in consequence. Could we but teach him that he wastes 20 per cent. of the sucrose when crushing his cane by a bullock-driven mill and that all told a loss of nearly 35 to 50 per cent. occurs in the whole process from the time the cane is cut to the complete manufacture of raw sugar, he would soon realize why it is that cane cultivation does not pay him as it ought to. The main point is that even with the existing varieties and the present low yields of cane per acre it is possible to make the industry more remunerative to the cultivator, to increase the supply of *gur* and make more raw sugar available in this country for refining, and thus indirectly to reduce her imports of foreign sugar.

Let us look a little more closely into the actual milling as done by the cultivator. With the ordinary 3-roller mill driven by bullocks, in the case of a cane having 8 per cent. fibre, and a total possible juice production of 89·3 per 100 of cane, the cultivator will extract *even*

under the most favourable circumstances only 74·9 per cent. of juice; while a Krajewski cane crusher and three 3-roller mills with maceration will extract 86·9 per cent. of juice. When the fibre content of cane is 15, the best 3-roller bullock mill will only extract 53 per cent. juice, while with the Krajewski cane crusher and three 3-roller mills with maceration the extraction runs as high as 75·5 per cent. out of a possible 80.[1] That is to say, where the fibre content is high the cultivator stands to lose much more with his present methods of crushing than in the case of canes with a low fibre content. It can be safely said that there is a loss of upwards of 20 per cent. of sugar with the methods of extraction now at the disposal of the farmer.[2] As a matter of fact we know that on account of the strain on the bullocks the mills are often slacked off and their efficiency consequently suffers still further. But just imagine what country or what industry could or would stand a waste of 20 per cent. occurring in a single operation, which is but a link in the whole chain of the process of manufacture, if it had any competition to meet. How can the cultivator find the crop a paying one nowadays when imported sugar manufactured with all the latest mechanical and chemical improvements is cheaper than the indigenous product? It was all very well in the days when there was no competition from the outside world; then the consumer had to pay a heavy price for the inefficiency of the cultivator as a manufacturer of sugar. But that is all changed now. The outstanding fact is that steam power must be employed for crushing cane wherever we can get a sufficient area for the smallest steam plant to run economically. Bullock power cannot successfully compete with it. In the case of cane there is an additional advantage in favour of steam power because the refuse of the cane, *i.e.*, bagasse serves as a fuel. Power crushing means quicker, cheaper, and more efficient crushing. Oil engines solely used for this purpose are handicapped for the following reason. Steam plant for sugar

[1] See table on p. 12 of "Muscovado Sugar Machinery and Its Scope for *Gur* Manufacture in India." *Bulletin No. 52 of the Department of Agriculture, Bombay.*

[2] See "Sugar and the Sugarcane in the Gurdaspur District," by the late Mr. J. H. Barnes. *Bulletin No. 69 of the Agricultural Research Institute, Pusa.*

factories is so devised as to run on bagasse alone and no extra fuel is required, whereas in the case of oil engines the cost of oil is a most substantial item. The losses that take place in boiling the juice are equally serious. This is only to be expected when we take into consideration the crude appliances at the disposal of the farmer and his natural lack of knowledge of the chemical processes involved in sugar boiling. The late Mr. Barnes[1] has stated that in Gurdaspur nearly one half (varying from 34 per cent. to 57 per cent.) of the sucrose in cane is lost in the whole chain of operations from milling to boiling. At present the juice is boiled in open pans direct over the fire. The heating surface thus provided is not large and the result is that a part of the crystallizable sugar is lost in inversion and caramelisation. If steam power is used it suffices both for motive power and for evaporation. In steam evaporation a large heating surface is provided and the losses due to inversion proportionately reduced. Steam heating is also more efficient than open fire heating. In modern sugar factories heat is economized by the use of "multiple effect" evaporators and vacuum pans. At present cultivators in India increase the manufacturing expenses by burning extra fuel whereas with the help of evaporators and vacuum pans in a *gur* factory they ought to be able to run with megasse alone particularly where the cane is very fibrous. The burning of sugarcane trash which is so common in some parts of India is equally wasteful; it can be utilized very profitably as manure. To get the full advantage of steam power we must resort to multiple crushing; to evaporate the juice with the expenditure of minimum heat energy and to obtain a better quality of produce we must resort to multiple evaporators. We condemn the open fire system because it leads to an increase in the glucose ratio, making the *gur* soft and sticky and liable to run in damp weather. Such *gur* provides very unsuitable raw material for refining. Under steam evaporation the increase in the glucose ratio is not as great and hence better quality *gur* is produced to the great advantage of the refiner. From every 100 maunds of *gur* as prepared by the country method a refiner is lucky

[1] *Loc. cit.*

to get 55 maunds of sugar, whereas from the same quantity of *gur* evaporated by steam he will be able to recover 10 to 15 per cent. more.[1] It may be argued that crushing his own cane is a case of " Hobson's choice " on the part of the cultivator. But it is surely to the advantage of the community, as a whole, for the State to come forward and show the cultivator how best the crushing can be done, put up efficient installations at some centres, charge reasonable rates for crushing and manufacture of *gur*, and thereby conclusively prove (by the only method possible) to the cultivators that these modern methods of crushing and boiling are very profitable. Once these are being successfully worked and the cultivators convinced of their superiority the promotion of steam factories for *gur* can be encouraged. In order to ensure the successful working of the factory the cane growers should be given some interest in it and the local *soukars* should be persuaded to take shares in it, or if this is not possible a Government officer, preferably of the agricultural department, should fix the price at which cane should be supplied to the factory so that it may be remunerative to both sides ; arrangements should be made by the factory for financing the cultivators so that they may not have to go to *banias*, but should look to the factory naturally for finance on easy terms. In Formosa the Sugar Bureau requires each mill to submit to it the scale of prices which it proposes to pay for the canes within its district, the object in view being that the farmers should get a fair rate. It is still open to question how far this Bureau has discharged its obligations towards farmers, but the principle is sound, and might, if worked equitably, do much good in this country. We are sure that under safeguards like these there will be no difficulty in running a factory. If the cultivator can get as much by selling cane direct as from *gur* manufacture, he will soon see the advantage and confine himself to his legitimate work of raising the crop and then selling it to those who manufacture it best. We mean to make it clear that even *gur* manufacture should no longer remain a cottage industry.

[1] See *Bombay Department of Agriculture Bulletin, No.* 52, for a fuller account of the advantages resulting from the use of steam power for crushing and evaporation.

Either the cultivators themselves should combine and work a *gur* factory, which I do not consider is within the range of practical politics at present, or else some other agency with proper safeguards should undertake the job. While several thousands of acres are required for a central factory, a few hundreds of acres will suffice for a *gur* factory. Experts are of opinion that such a factory can work successfully, if a minimum of 5,000 tons of cane is available within a radius of 4 miles.[1] This would postulate an area of some 250 acres actually under cane in any single year in the Deccan and Madras, while in Northern India some 400 acres will be required. An enquiry should be set on foot to find out the likely sites for the erection of *gur* factories and these should be published for the information of capitalists.

At this stage the question will naturally occur to the interested inquirer what should be done where cane cultivation is so restricted and scattered as not to come within the scope of central sugar factories or even *gur* factories. The answer is that in such parts the cultivators must adopt such cultural and other improvements as the Agricultural Department suggests; otherwise they will find the crop more and more unremunerative in future and will ultimately be obliged to give it up altogether, if there are no special causes favouring the crop in these localities.

We will now briefly refer to the sugar refining industry. It will be best if in parts like the Deccan the factory works as a combined one for the production of *gur* and refining sugar. This will present no difficulty. In the off season it can refine inferior *gur* or imported raw sugar, this will not materially increase the cost of the factory, because for refining we only need to add a blow up tank and a bag filter. Thus when *gur* is dearer than sugar the factory can manufacture *gur*, but when this stuff is cheap it can do the refining work. In this connection we venture to think that a revision of the sugar tariff appears necessary.[2]

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[1] The factory will pay best if it crushes 100 tons of cane per day or 10,000 tons in the whole working season. A correspondingly increased area under cane will in that case be required. [W. S.]

[2] See "Indian Sugar Tariffs and the Indian Sugar Refining Industry," *Report of the Ninth Indian Industrial Conference*, 1913.

In India there is at present an *ad valorem* duty of 10 per cent. on all imported sugar irrespective of the fact whether the sugar is white or semi-white raw sugar (grey crystals) 15 D.S. and under. Now we venture to think that it is not economically sound to go on importing refined white sugar when we can import the latter and refine it here. There is always a difference in the price of these two classes of sugar which corresponds to the cost of refining. Now in order to enable the local refinery to work at a profit differential rates of duty should be levied on these two classes of sugar. In Great Britain before the war the duty was 1*s*. 10*d*. per cwt. of white sugar while it was only 10*d*. per cwt. of raw sugar. The difference of 1*s*. per cwt. represents the refiner's profit. The *ad valorem* duty in India does not leave sufficient profit for the refiner. This is clear from the following table :—

	Price per cwt.			10 per cent. duty		
	Rs.	A.	P.	Rs.	A.	P.
Sugar, crystallized and soft, from Java, 16 to 22 D. S. ...	14	8	0	1	7	$2\frac{2}{5}$
Sugar, crystallized and soft, from Java, 15 D. S. and under ..	12	0	0	1	3	$2\frac{2}{5}$

The difference of 4 annas per cwt. is not sufficient for a refiner, being only one-third of what it is in Great Britain. The duty should be made *specific*, say Rs. 2 per cwt. for white sugar of 16 D.S. and above, and only R. 1 per cwt. for sugar of 15 D.S. and below. This will enable several refineries to be put up in those parts (Calcutta, Madras, Bombay) which on account of their proximity to the sea have felt the force of foreign sugar competition the most. The profits of a refinery being steady, it will give a great impetus to the Indian sugar industry. Before the war we used to import about 500,000 tons of white sugar (16 D.S. and above) per year. This shows that there is wide scope for refineries in India to work successfully, provided a revision of tariffs is carried out. It will be argued that this will transfer to the pockets of the refiners the money which should go to Government. To this we reply that the money will at least not go to Java and other countries. It will create a local refining industry while it will in no way increase the price of the commodity to the consumer. Government will also not suffer any loss

in revenue if the scale of tariffs is so adjusted as to realize the whole or a major portion of the required revenue from the duty levied on raw sugar, the importation of the refined product being discouraged by the imposition of a higher duty.

To sum up. It has been made clear that the problem of the Indian Sugar Industry is a two-fold one, and energetic measures should now be set on foot to place both the *gur* and the white sugar industries on a satisfactory working basis ; to do this properly will require a survey to be made of the localities where white sugar factories can be erected and at the same time the districts where the cane cultivation is only capable of carrying a *gur* factory should be carefully recorded. The financial side of the matter and the question of State assistance to the pioneer factories also require to be carefully examined. To do this will require a strong committee of experts who will also be able to report to Government how far the manufacture of sugar on a considerable scale, together with its by-product—alcohol—can be made the subject of excise control in India. The question of the creation of a special sugar department for India for tackling and co-ordinating the numerous manufacturing, agricultural, botanical, and chemical problems connected with the industry could also be dealt with, but the main question is to get it dealt with at once, for, at present, Indian sugar is being made under most favourable conditions, and this state of things, which gives an insight into the possibilities of the industry in India, when foreign competition is lacking or curtailed, will not last for long, and if the industry which is now in places getting its head above water is allowed to be stifled again by unfair competition it will not readily respond to efforts made in the future to resuscitate it.

[*** The Editor will be glad of criticisms of this article from readers who have had experience of the sugar industry in India.]

THE LATE MR. JAMES HECTOR BARNES, B.Sc., F.I.C., F.C.S.

JAMES HECTOR BARNES was born in the year 1879 and was thus only just over 38 years old when his untimely death cut off a career of great promise and robbed the Agricultural Department of one of its greatest personalities and ablest thinkers. Before entering College he was apprenticed at the Chemical Works of Sir T. Barclay of Birmingham. He thus entered College later than usual. This early commercial training had great influence on his character and way of looking at things. At the University of Birmingham he studied Chemistry under Frankland and Physics under J. P. Thomson, both men in the first rank in their respective spheres of scientific work. It is to his home, however, that we have to look for the basic influences which moulded so strong a character and which fitted it to receive the best from the able men he came in contact with in his early life. His mother who is still living had probably more influence on his character than all other persons combined. The writer had the pleasure of many conversations with her at the Briars, Birmingham, and would take this opportunity of paying homage to a charming personality and one of the most intellectual women he has ever met. Her strong convictions and ideals were reflected in every phase of her son's life nor was he ever ashamed to acknowledge his debt in this respect.

Mr. Barnes came out to India in October 1906, being one of the men selected by Mr. Mollison, the late Inspector-General of Agriculture. He was posted to Lyallpur in the Punjab as Agricultural Chemist and became Principal of the College in 1908 on Mr. Dobbs' transfer to Bengal. His first duty at Lyallpur was the planning and fitting out of the Chemical Laboratory, the College buildings not having been started—they were opened for students only in

PLATE XXXIX.



THE LATE Mr. JAMES HECTOR BARNES, B. Sc., F.I.C., F.C.S.,
IMPERIAL AGRICULTURAL CHEMIST, PUSA.

August 1909. He gave most minute attention to detail with regard to the Laboratory, which is now probably the best fitted in India. Dr. Smithells of Leeds and Dr. Wyndham Dunstan of the Imperial Institute who visited Lyallpur in 1913 and early 1914, respectively, testified both to the thoroughness of the equipment and the scope of the scientific work in progress. The College workshop was inaugurated by him and under his guidance many valuable instruments have been manufactured for scientific work, which could not have been obtained elsewhere. Looking broadly at his chemical work, one is struck with the copiousness of the ideas underlying it and of the many inventions of apparatus and methods which the conduct of the work involved. It is possible, as he himself used to point out, that the methods and apparatus were crude and no doubt many improvements can be made in them, but pioneer work of great value has been done and will be generously recognized by all true scientists. Among other lines of work may be mentioned, (*a*) study of salt lands and their reclamation together with biological methods of determining fertility of soil, (*b*) study of seepage and rising of ground water-level under irrigation conditions, (*c*) the sugar industry and sugarcane in the Punjab, (*d*) determination of the intensity of the Sun's rays (a problem which may have a bearing on the solution of 'soaring flight'), (*e*) the Kangra tea industry, (*f*) the chemical aspect of weevil attacks on wheat. Several miscellaneous papers were published, such as "Chemical Constituents of Cotton Lint," "Chalybeate Deep Well Waters in the Punjab," etc.

Many of these problems are such as will require many years of patient work by many investigators and for that reason would not have appealed to many scientists with a limited time for scientific work. In the study of each of them, Mr. Barnes brought forward novel ideas and methods capable of development by subsequent investigators. The bigger the economic problem the more he was attracted to its solution. It was not a case of dabbling in many things—some real light was thrown on some aspect of each big question attacked. This is why one is bound to feel that his published papers, which are on particular definite pieces of research, give no adequate idea of the whole. It may be truly said that the work

was far greater than the papers and the man himself greater than all. He had a remarkable power to interest others in his work. One of his last conversations with the writer was regarding the development of the chemical side at Pusa and the founding of a School of Chemistry there--an idea which it is to be hoped will not be allowed to die.

As Principal of the Agricultural College he gave the institution of his best at all times, though suffering from very indifferent health during the last few years. On the occasion of his departure from Lyallpur in February last, a large subscription was collected by the Indian staff which enabled us to institute, among other things, an annual prize in his honour together with the presentation of a life-size portrait for the College Library. Both of the above will be a source of encouragement and inspiration to future generations of students. His high sense of integrity and fine ideals will leave an indelible impression in the Institution to which he gave so much and for which he worked so hard.

Mr. Barnes married, in December 1914, Nora, daughter of the late Colonel Francis Thomas Ebden, Indian Army. The sympathy of all his friends and admirers will be with Mrs. Barnes in her sad bereavement.—(W. R.)

THE WORK OF THE FOREST DEPARTMENT IN INDIA: A REVIEW.*

BY

J. MACKENNA, C.I.E., M.A., I.C.S.,

Agricultural Adviser to the Government of India.

SOME two years ago the writer of this review was entrusted with the duty of compiling a popular summary of the activities of the Agricultural Departments of India. It is therefore with considerable personal interest that we welcome the brochure before us which contains an account of the activities of our great sister department of forests. And this little summary is the more welcome that it gives us a concise description of work, the actual details of which in practice it is given to few of us to see. At the beginning of the camping season the forest officer vanishes from our ken into the vast expanse of jungle with his tents, his elephants, his stores and office equipment, and he returns at the break of the rains a swarthy figure oft "bearded like the pard." His occupation in the rains is his Annual Report, and one hears a good deal about that: what he is doing in the long months of winter few of us know. We hear such phrases as "working plans," "girdling," "fire protection," etc., but to the ordinary layman these signify little or nothing. The work of the forest officer lies for the most part in remote places and far from the beaten track so that few of us have any knowledge of it. If we do penetrate the forest glade it is for a Christmas shoot—but into the mysteries of our host's daily labours we are not admitted.

* The work of the Forest Department in India, edited by R. S. Troup, Assistant Inspector General of Forests. Superintendent, Government Printing, India, 1917, Price 4 annas.

I have referred to Agriculture and Forestry as sisters though I am aware that some count her the handmaid of agriculture. But agriculture might be called a "fast young woman." We get results in agriculture rapidly, and they are results which attract attention and keep us in the lime-light. In forestry the case is different. As the writer of the introduction to this booklet says: "The practical results of forest work are apparent after long periods of time, so that the forest officer has to cultivate the habit of thinking in half centuries and to be content that the full effect of his labours shall be visible only to future generations."

In the monograph before us the veil is lifted and it is given us to see what are the vast labours and responsibilities of our Forest Department. The opening pages show that forest matters occupied in the early days even less of the attention of Government than did agriculture. It was not till 1855 that Lord Dalhousie laid down a definite and far-sighted forest policy. It was the necessity of saving the valuable teak forests of Lower Burma that prompted this policy, and the appointment of Dr. Brandis as Superintendent of Forests in Pegu in 1856 marks the dawn of scientific forestry in India. Out of these small beginnings has grown the Forest Department of India consisting on the 1st July, 1916, of the Imperial Service with 237 officers, the Provincial Service with 231 officers, and a subordinate service numbering over 14,000.

This staff, we are informed, has to deal with more than one-fifth of the total area of British India (including the Shan States), the total forest area on the 30th of June, 1915, being 249,867 square miles. The areas under the control of the Forest Department are broadly divided into four classes :—

1. Forests, the preservation of which is essential on climatic or physical grounds.

2. Forests which afford a supply of valuable timbers for commercial purposes.

3. Minor forests containing somewhat inferior kinds of timber, and managed for the production of wood, fodder, grazing, and other produce for local consumption.

4. Pasture lands, *i.e.*, grazing grounds managed by the Forest Department merely as a matter of convenience.

The first class of forests are protected for their indirect effects and with no commercial objective. The second class are the commercial forests of teak, *sal*, (*Shorea robusta*) pyinkado, (*Xylia dolabriformis*) deodar (*Cedrus Deodara*), and pine which are managed mainly with the object of providing the greatest possible out-turn of timber for commercial purposes. The third and fourth classes contain the areas which are managed mainly, if not entirely, for the production of the forest produce necessary for the requirements of the local population.

In 1913-14 this amounted to—

Timber ..	..	7¾ million cubic feet.
Fuel ..	..	59 million ditto.

Bamboos : nearly Rs. 88,000 in value.

Grazing and fodder grass : nearly Rs. 33 lakhs in value.

It will thus be seen how diverse and varied are the duties of our Forest Departments.

Now when a natural forest tract is first taken in hand it is generally found in a jumble of entanglement : and to introduce orderly management into disorder is the first task of the Forest Department. A programme or "working plan" has to be drawn out setting forth the general objects to be attained and prescribing for a series of years the operations to be carried out in order to achieve these ends. The ultimate object is the economic exploitation of the forest : and a "working plan" aims at laying down what and how many trees can be removed annually; and how the annual depletion is to be made good by spontaneous regeneration or by planting up young trees.

Then there is the formation and maintenance of plantations and the protection of the forests from injury by fire or illicit lopping, felling and other abuses. All this is the internal economy of our forest management before we come to exploitation by the Department or by contract purchasers. And apart from the technical and commercial aspects there is the revenue collection to be attended to. A forest officer's work is many-sided.

A considerable part of this little book is devoted to a necessarily brief account of some of the more important major and minor forest products of India: while another section deals briefly with forest industries—the Indian pine-resin industry, the paper pulp industry, and the match industry. The antiseptic treatment of timber and the dry distillation of wood are also dealt with. With these more technical sections we do not propose to deal: the interested reader can refer to them for himself.

We shall conclude our review with a reference to the research work of the Department. Just as in the case of agriculture, a good deal of spasmodic and individual experiment was carried out in the early days. But this was not systematized and the greater part of it was lost. Since 1906, however, an attempt has been made to organize forest research and at the Forest Research Institute at Dehra Dun such branches of research as Sylviculture, Forest Botany, Forest Economic Products, Zoology, and Chemistry are dealt with. In addition special officers are appointed from time to time for special enquiries, while apart from the centralized research work at Dehra Dun officers in Provinces undertake special local investigations in communication with the Central Research Institute.

It only remains to add that Mr. Troup's review is very liberally illustrated and we can commend it to any one interested in Indian forests as a simple and interesting account of the activities of the Department.

SOME BREEDING STATISTICS.*

BY

R. BRANFORD, M.R.C.V.S., I.C.V.D.,

Superintendent, Government Cattle Farm, Hissar.

THE following notes may be of interest to breeders and students of Mendelism.

(1) *Colour in Mules.* My experience of mule breeding has been confined to breeding mules for the Army. The Army require mules up to various standards of measurements for different purposes, and always prefer them "dark-coloured"; greys, even dark-iron greys, are always liable to be rejected, possibly owing to the tendency of even dark-greys to lighten in colour with age. Hence my experience has been confined to the use of dark-coloured donkey stallions, except a few cases in which "Mouse" coloured donkeys have been used. The following are particulars as regards 219 mule foals bred in recent years at the Government Cattle Farm at Hissar:—

111 mules bred from 42 bay or brown mares by black or dark-brown donkeys were all bay or brown.

6 mules from the same mares by mouse-coloured donkeys were also all bay or brown.

41 mules from 13 chestnut mares by black or dark-brown donkeys were all bay or brown.

1 mule from a chestnut mare by a mouse-coloured donkey was a bay.

20 mules from 13 roan mares by black or dark-brown donkeys were 18 bays or browns, and 2 duns.

* Received for publication on 14th May, 1917.

27 mules from 14 grey mares by black or dark-brown donkeys were 18 bays or browns, 6 greys, 2 duns, and 1 mouse-coloured.

6 mules from grey mares by mouse-coloured donkeys were all bays or browns.

4 mules from 4 dun mares, 3 by black or dark-brown donkeys and 1 by a mouse-coloured donkey, were all bays or browns.

3 mules from 2 skewbald mares by black or dark-brown donkeys were all bay or brown.

From the above figures one may assume that using dark or mouse-coloured donkeys and bay, brown or chestnut mares, one may be certain of getting a mule of a colour suitable for military purposes. Almost certainly the mules will be bay or brown. As would be expected, chestnut being recessive in horses and not being a donkey colour, chestnut is a rare colour in mules. It does, however, occur. Of 1,200 mules described in one of the Farm registers, 8 were chestnut. No chestnut mule has ever been foaled on the Farm, and I do not know from what coloured parents the chestnuts occur. It also seems reasonably certain that roan, dun, and mares with any considerable patch of colour piebald or skewbald, if covered by dark-coloured donkeys, will produce dark-coloured bay or brown mules. The patches of colour on two of the skewbald mares, bred from here, are very faint. At a distance the mares look white, 3 mules from them are all dark bay. The 13 roan mares bred from are of all shades of roan, chestnut, strawberry, and blue. Some are very light in colour, with the great majority of the hairs white. Eighteen of their 20 mule produce are distinct bays or browns, without the trace of a white hair. The two duns were both dark enough to be accepted by the Army.

The tendency of the grey horse and mule to become lighter in colour with age causes difficulty in the compilation of accurate statistics as regards this colour.

So far as my experience goes, mares with dark manes and tails nearly always produce true bay or brown mules.

Certainly 4 mules recently produced by such mares have been true bays without any tendency to become grey.

Undoubtedly the practically all white mare also sometimes produces true bay mules, but the fact that the mules are in any case born black or brown, and if they become grey at all become more so as each successive coat is shed, is always liable to cause error in descriptions.

As pointed out by Professor Wilson in his "Manual of Mendelism," the colour of the donkey appears to be almost invariably recessive to that of the horse.

However, mouse-coloured mules as distinct from duns, similar in colour to the mouse-coloured donkey, with the same Zebra stripes across the wither and leg are not uncommon. One bred on this Farm was out of a grey mare by a brown donkey.

White markings on the head and legs so common in horses are very rare in donkeys and seem to be even more rare in mules. I have never seen a mule with any white on his legs, and can only recall two with stars. The factor for whole colour in donkeys appears to be dominant to the factor for broken colour in horses.

Three Zebra hybrids, two from chestnut mares and one from a skewbald mare, were bred and reared on this Farm. All were approximately the same colour and the Zebra markings are very distinct in all, very much as depicted in Professor Cassan-Ewart hybrid "Romulus," but the ground colour is not quite the same as any horse colour, it most nearly approaches light bay, but is distinctly more yellow.

Donkeys. My experience has been confined to breeding or attempting to breed donkey jacks suitable for breeding a good class of mule, preferably one suitable for military purposes.

Dark-coloured jacks are preferred and only dark-brown or black and occasionally mouse-coloured donkey stallions have been used. As many as possible of the mares used have also been brown or black, but a few mares of other colours, *viz.*, mouse, grey, and white have also been used.

Those described as white are not of course albinos, parts of the skin, notably lips and udder, are generally black, but they are born with all the hairs white and remain white.

The four mares used were purchased animals and probably were from white parents; there being a breed of white donkeys in the Punjab, which probably breed true, although I can produce no statistics to prove the point, and no doubt as is the case with all stock in India as a rule no trouble is taken to keep the breed pure.

Some dark-coloured donkeys have light-coloured muzzles, bellies, and round eyes. Greys are usually a more or less even mixture of white and dark hairs, but are sometimes dappled.

The following statistics have been collected from Farm registers. The liability to error in describing grey is very great, and largely discounts the value of the figures :-

(1) 93 foals from 16 brown mares by black or dark-brown stallions were 82 brown, 8 grey, and 3 mouse.

Four from brown mares by mouse-coloured stallions were 2 mouse, 1 grey, and 1 brown.

(2) 37 foals from 9 mouse-coloured mares by black or dark-brown stallions were 14 mouse, 17 brown, and 6 grey.

One foal from a mouse-coloured mare by a mouse-coloured stallion was mouse-coloured.

(3) 19 foals from 4 white mares by black or dark-brown stallions were 12 grey, 1 brown, and 6 mouse.

(4) 58 foals from 13 grey mares by black or dark brown stallions were 26 brown, 5 mouse, and 27 grey.

The dark-brown or black donkeys generally seem to breed true. The produce of 9 of the mares by black or dark-brown stallions were all brown or black.

The greys probably occur when one of the parents is not a pure brown or not wholly brown. Dark-coloured donkeys with a few white hairs interspersed in their coat are common. At present I have two 4-year old jacks, both the produce of dark-brown mares and stallions, both are practically black, but both have a few white hairs especially about the head and neck. One at six months was described as a grey.

The tendency so marked in horses and mules for greys to become lighter in colour with each shedding of the coat, does not apply to

donkeys; the reverse is generally the case. I have several practically black donkeys, which were quite grey at 6 months of age.

It would be interesting to breed grey mares with a grey jack and mouse mares with a mouse jack. Possibly the produce of greys might split up into whites and dark-browns or blacks, but white and light-greys being unpopular colours, it is not likely I shall ever have an opportunity to use a grey jack.

Sheep. The produce of black-faced crossed with white-faced sheep is said to be grey-faced. I expected to obtain similar results by crossing black-wooled with white-wooled sheep, but recently I bred 5 black ewes to an Australian white Merino ram, and the lambs were all black exactly like their mothers.

The ewes are all black with a white tip at the end of the tail, and some have a white patch on their forehead. Colour at birth is coal black, when mature they fade to a rusty black. Two of the ewes have lambed twice, so altogether 7 black lambs have been born to them, by a white ram.

Five of the lambs are females, when old enough they will be bred to one of the cross-bred black male lambs.

Cattle. Recently I received a complaint that the produce of a red Sihwal bull sold from the Farm, which was being used with a herd of red cows, were all white. I have had no opportunity to investigate the matter, but as red cattle usually breed true to colour, probably some other bull has had access to the cows. Various colours are claimed to be typical of Sihwal or Montgomery cattle, but reds are generally preferred. Only a small number of these cows are maintained on this Farm, most are red and only red bulls are kept.

Of 50 calves from red cows by a red bull recently born on this Farm, 48 were red and 2 grey.

Birth Statistics. The proportion of male to female births is a question which appears at times to excite some interest.

I append a list showing the number of male and female calves born on this Farm, during the last 10 years.

Statement showing the number of calves born during the last 10 *years.*

Year	Male Calves	Female Calves	Total
1906-07	315	267	582
1907-08	292	285	577
1908-09	406	381	787
1909-10	318	345	663
1910-11	429	380	809
1911-12	372	367	739
1912-13	326	297	623
1913-14	376	407	783
1914-15	446	398	844
1915-16	583	521	1,104
From 1st April to 31st December 1916	64	67	131
TOTAL ..	3,927	3,715	7,642

During approximately the same period, 258 female and 272 male donkeys have been born, as shown below :—

Year	Colts	Fillies	Total
1906-07	18	9	27
1907-08	25	26	51
1908-09	17	17	34
1909-10	26	19	45
1910-11	19	17	36
1911-12	37	31	68
1912-13	32	31	63
1913-14	21	29	50
1914-15	30	23	53
1915-16	31	31	62
From 1st April to 31st December 1916	16	25	41
TOTAL ..	272	258	530

CATTLE ROPES.*

BY

R. CECIL WOOD, M.A.,

Principal, Agricultural College, Coimbatore,

AND

S. SUBRAHMANYA AYYAR,

Farm Manager, Central Agricultural Station, Coimbatore.

A CERTAIN amount of experience has been gained at the Central Farm, Coimbatore, in the matter of tying cattle in the stalls and providing them with the necessary driving ropes, and an account of the system may be of interest to others in similar circumstances. The problem must have presented itself before, notably, we should think, to the Supply and Transport Corps, and this note will perhaps induce others to place their experience on record.

The main difficulty was to stop the leakage of ropes which disappeared to an alarming extent. For the 60 pairs or so which are kept here, about Rs. 300 used to be spent annually, and even then there was always trouble when a student wanted to take a pair out for work, from the ropes being too short or worn out.

Formerly the animals were tied in the stalls with their own head ropes, which were thus part and parcel (until they were stolen) of the animal itself. They could not be simply taken away, because the animal would at once have proclaimed the loss by walking about, but they were undoubtedly exchanged.

The exact method of attaching the head rope may be noticed here, as in other parts of India various methods have been seen

* Received for publication on 11th April, 1917.

which are possibly less efficient. The illustration (Plate XL, fig. 1) will probably make this clear, without the need of much description. Briefly, there are three units : the nose rope, the head band (usually a strip of leather which may be ornamented), and the driving rein. By passing the slack of the nose rope through the headband, the pull, whether the man is in front of or behind his animal, is always upwards and against the cartilage of the nose.

The first step was to make each man responsible for his own ropes, and this implied their removal from the animal when not at work. To tie the animals in the stalls, light chains were introduced and have been found quite satisfactory. These are 4 feet in length, and cost complete, 6 annas : one end is fastened to the manger by a simple attachment, and the other has a ring and bar which can be easily slipped over the nose rope. The method of attaching the cattleman's ropes to the nose rope was next considered. A swivel spring clip would have been preferable, but was found too costly : and eventually the rope end was divided into two, one having a loop and the other a knot. If the ends are of different length, the pull does not come directly on the knot (Plate XL, fig. 1).

This was so far satisfactory. The men were given their own ropes, and were held responsible for them, each attaching tufts of various coloured wool to mark his own. There were a few animals such as the stud bulls which were not regularly taken out for work, and for whom permanent ropes were considered necessary. It was then decided to apply to the local jail for a sealed pattern of cotton twine, which was issued only to us. The theft of this would have been accompanied by difficulties, as so long as there was a rope at all, so long would there have been a blue cotton thread intertwined in it, by which it could be identified. This step led on to a further difficulty, the manufacture of nose ropes out of this special twine. Some were bought and carefully untwisted to see if the secret could be unravelled, but to no purpose. In South India, the art is in the hands of a few Mahomedans who will not reveal it but keep it as a close trade secret. M. R. Ry. Rao Bahadur Abraham Pandithar of Tanjore, thinking that he could manage to get hold of a



Fig. 1.

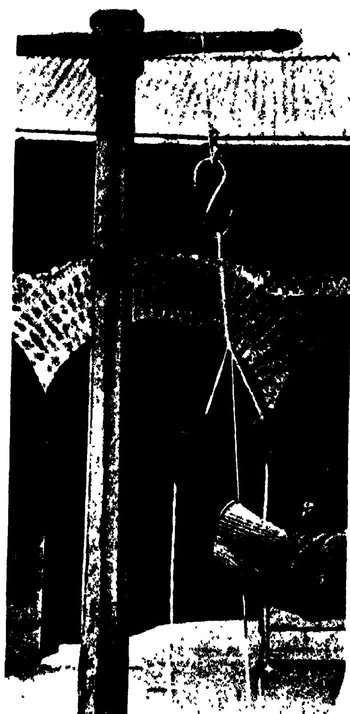
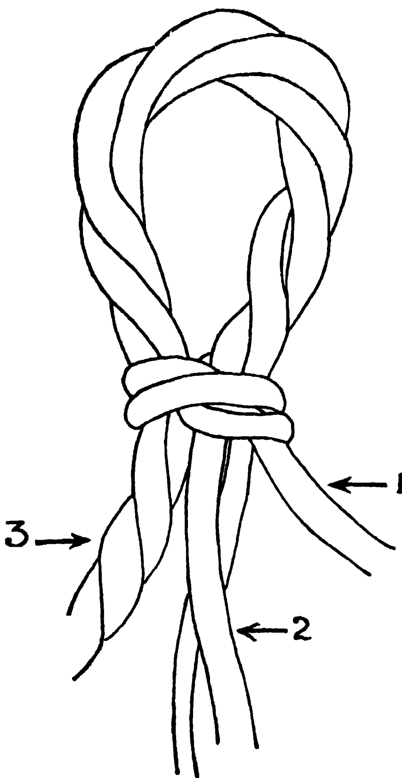


Fig 3.



Fig. 2.

Mahomedan of his place for the purpose, kindly consented to train one of our farm men who was accordingly sent to Tanjore. Our man was allowed to be present for a little while in the rope-making yard, but when in the course of their conversation the Mahomedans learnt that our man had gone there to learn the art, their anger was roused and they would have handled him severely had he not, with the assistance of the men who conducted him there, narrowly escaped and promptly returned home with a rope-making apparatus which Mr. Pandithar managed to buy for the farm use. This machine is shown in operation in Plate XL, fig. 2, which almost explains itself. Its object is to give a good twist to the single twine before making it up into a rope. It consists of two small iron rods (each ¼ inch thick by 2 feet 2 inches long) inserted parallel to each other in two holes made about 2 inches apart in two flat pieces of iron affixed to the stand; the rod has a notch about two inches from the end to control its play when turned. The ropes are made from cotton twine, six twists making one rope. Accordingly twine about six times the required length of the nose rope is taken, plus about 18 inches; one end of it is firmly held by one of the rods at its end and a man holds the other end of the twine at a distance. Another man takes hold of a strong rope 4½ feet long, and doubles it round the rods as shown in the photo. When this rope is drawn backward and forward, the rod holding the twine turns only in one direction, thus giving the twine a good twist. When the required twist is got (and this is gained by experience), the twine is folded into three without allowing



1. Single strand.
2. Double strand.
3. Treble strand rope.

it to kink and then twisted on itself carefully—starting from the end away from the machine—to form a rope. When the three strand rope is thus twisted half its own length, it is removed from the machine and doubled, and a loop made at the doubled end; the loop being secured by knotting the single strand round it (*see* Text-figure, p. 581). Round the single twine held in position by a sling at the top and the toe below, the double and treble strands are now twisted (Plate XL, fig. 3). Thus a nose rope tapering at one end and with a loop at the other is got. Such nose ropes are now easily made on the Central Farm with the special twine prepared for us by the Central Jail, and are used for the farm cattle. Three men can in a day prepare 60 nose ropes and more with experience. The cost is about three annas and six pies each. It is now nearly a year since these ropes have been in use on the farm, and there has not hitherto been a single case of theft.

To make the set complete, chrome leather was substituted for ordinary leather for the head bands. These cost four annas each and have proved satisfactory.

SOME OBSERVATIONS ON AGRICULTURAL WORK IN EGYPT, AMERICA, AND JAPAN.*

I. EGYPT.

BY

W. ROBERTS, B. Sc.,

Professor of Agriculture, Lyallpur, Punjab.

I ARRIVED in Egypt on the morning of the 10th of May, 1916, and proceeded direct from Suez to Cairo. During my stay of eleven days I was able to obtain a very fair insight into the work in progress, as every facility was given to me through the kindness of the High Commissioner (Sir Henry McMahon). I confined my enquiries to three main heads here as elsewhere, *viz.*—

(*a*) The cotton work.

(*b*) Success in introduction of agricultural improvements.

(*c*) Education, especially elementary agricultural education.

Cotton work. The botanical work is now in the hands of a new botanist who was appointed after Mr. Balls left. A great deal of what may be termed preliminary work is on hand not only on cotton but on other crops as well. While there is evidence of plenty of energy in the work, it would be unwise to expect any big economic results until much more experience has been gained. As regards seed distribution, there is a good scheme on paper, but as far as I could make out, there was little pure seed to distribute which was of proved superiority over what is grown at present. I was under the impression (*vide* A. S. Pearse's report, page 184, ***Proceedings of the Board of Agriculture in India held at Coimbatore in 1913***) that

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seed distribution was on a much more thorough basis than in India, but on meeting officers from the Soudan and discussing the matter, it turns out that the scheme mentioned in Mr. Pearse's report only refers to Government estates where very direct control can be exercised. No such policy as compulsory seed buying is in vogue in Egypt proper. As to demonstration work, we have heard a great deal about the scheme of taking over a farmer's field and for growing his cotton for him and thereby showing how superior the Government method was, and this scheme has been warmly advocated by Mr. Pearse (*see* above report of Board of Agriculture) for India and some sympathy for it has been in evidence through various amateur pioneers of agricultural improvement. The system is still carried on in Egypt, and the Agricultural Department had as many as 18 such fields for cotton alone in 1914, and in about 17 of these, successful results based on statements made by growers as to surrounding crops are claimed. When asked to state what particular points the improvements are attributed to, the answer is vague and generally reduces itself to " Oh, we do all the operations at the right time, including watering, etc." Can the cultivator always water at the right time ? No ; owing to rotations of canal supply, this is not always possible. I cannot too strongly condemn this system and its many evil effects. I find it quite impossible to accept the rosy view of this matter presented in the official reports, as it is scarcely likely that any young agriculturist deputed by Government can equal, much less beat, the industrious fellah at his main job, and until more definite points where improvement is being made are laid down the " good results " must be accepted with great scepticism.

As regards the general cultivation, one instructive feature stands out, *viz.*, the fact that rotations in the canal are in force during the early stages of the crop and that water is practically unlimited from June 1st or just before flowering. This seems to be in many respects ideal for irrigated cotton in a hot country, and here there may be a lesson for the Punjab where frequently excess of water is apt to be given in the early stages of the crop, causing heavy vegetative growth, and too little water after the flowering period.

It was with regard to the diseases of cotton and their control that Egypt appeared to me to be well ahead of India. In this respect a great deal is being done and the regulations against the importation of foreign seed seem wise. Some Indian cotton used to be imported until a few years ago for local spinning mills, but as Pink Bollworm is supposed to have been introduced in that way, all import has been stopped. In this connection I may mention that in the United States of America a different plan has been adopted, *viz.*, compulsory fumigation of all foreign cotton imported. In view of the importation of American cotton into India and the great danger of the introduction of the boll-weevil which has caused such havoc in the States, this matter might well receive serious consideration in India.

In Egypt cotton sticks have to be burnt or destroyed by May 1st and must be taken from the fields by December 31st preceding this according to a recent law. Cotton is so vital to the prosperity of the country that drastic measures such as the above may be feasible. It is open to some doubt, however, whether natural checks are not the real cause of the mitigation of the severity of certain pests, *e.g.*, the Cotton Leaf Worm and the Pink Bollworm. It is necessary to emphasize the fact that in Egypt cotton not only yields much more per acre than in India (average 400 lb. lint per acre) but is also nearly twice as valuable, *i.e.*, from 9*d.* to 11*d.* per lb. when Indian cotton is 5*d.* An average crop of cotton in Egypt is worth Rs. 250 per acre. This is so much more valuable than any other crop grown on any scale that the whole prosperity of the country depends on its cotton crop: hence disease has to be combated rapidly without undue waste of time of investigation.

Pressing and ginning. The gins used are similar to those of India—mostly McCarthy Roller Gins. The presses, however, are different and compare more to the presses of the United States of America than to the presses in India. They differ from the United States of America, in that a very large bale—710 lb. nett—is produced. The compressing is done very much better than in the States, as new cloth is used and complete repressing takes place. The Egyptian bale is, therefore, very much more compact and

better packed than the American. India, however, leads in regard to good pressing, and we have nothing much to learn from Egypt in this respect. I give below a few facts regarding bales in the United States of America, Egypt, and India :—

	Weight of bale (gross)	Measurement	Density per cubic foot in lb.	Weight of canvas and iron hoops (Tare)
	lb.			lb.
Indian	400	49″ × 20″ × 17″	42·8	8
Egyptian	740	52″ × 21½″ × 32″	35·8	
American	500	58″ × 29″ × 22″	23·0	29

In some cases Indian bales have even a much higher density than above. In this connection "The World's Cotton Crop," by Professor Todd, page 126, may be consulted, from which a different impression is gathered. Mr. Pearse in his latest report gives figures practically identical with those given by me (page 231, *Indian Cotton*, 1914).

Posting of prices in Halaquas or markets. Egypt is a very small, highly developed country with telephone connection from Cairo and Alexandria to all parts of the country. It is a very simple matter, therefore, to put up Alexandria, Liverpool, and New York prices in the various markets in the interior, and there is no doubt the system is very useful. In India the conditions are different, and we are not dealing in such a high grade article as Egyptian cotton. I consider, however, it would be very advisable that the Agricultural Officer at Lyallpur should receive Bombay prices daily, and also Liverpool, New York, and New Orleans prices if possible. As to district markets, the Lyallpur prices might be put up in all such places as Jaranwala, Tandlianwala, Gojra, etc., etc. The prices in these places often differ very much from Lyallpur prices. Montgomery markets likewise should receive Lyallpur prices daily until the market there is more settled. I have plenty of evidence that right up to our auctions in Montgomery, American cotton was selling at Rs. 8 and Rs. 9 a maund, whereas sale prices went up to Rs. 17-1

and the general market next day went up to Rs. 13 and Rs. 14 per maund.

Agricultural education. In Egypt, as well as in America and Japan, great interest was being evinced with regard to agricultural education. This was specially so as regards agricultural schools. The Egyptian Government are now proposing to start about 30 Farm or Elementary Schools where agriculture will be taught in the third year. The idea apparently is to develop these into technical schools, some of which will specialize in subjects like horticulture, dairying, etc., etc. There are at present in the country four Intermediate Technical Schools where pupils from 16 to 21 years of age attend. Each school has from 90 to 100 pupils. These schools started work four years ago, and it is from them that it is hoped to get teachers for the farm schools or elementary agricultural schools. These intermediate schools give a three-year course and have a staff of eight or nine assistants each.

AWANKARI CATTLE AT PESHAWAR.*

BY

W. ROBERTSON BROWN,

Agricultural Officer, North-West Frontier Province.

A RIDE in April over part of the Peshawar valley would make glad the heart of our Imperial Economic Botanist who so persistently and ardently advocates the more liberal use of clover in the rotation of crops in North-West India. Here, under the red-hot glowing Afghan hills, in one of India's hottest, driest parts, where no crop and very few trees could exist without irrigation, *shaftal* (*Trifolium resupinatum*), deep, cool, and lush green is *everywhere*. In viewing the plenteous scene, a rider must keep his mount well in hand for the tempting breadths of *shaftal* are always sopping wet or actually flooded, as every straight rider to hounds in the Peshawar Vale Hunt can tell. Here the Kabul river is verily "Father and Mother" to the agriculturists, and to the most tactful teaching of the Agricultural Department the stout Pathans just murmur "water."

During its brief life of eight months, *shaftal* certainly requires much water; it is irrigated, if so much water can be obtained, no less than 14 to 20 times between 1st October and 15th June. Happily, the Peshawar canals, unlike those of almost any other part of North-West India, afford sufficient water for *shaftal*. Clover, then, mixed with *bhusa*, enough and to spare, is or should be in every Peshawar manger between November and June. In September seed is broadcasted in growing maize when that crop is three feet high; or *shaftal* is sown in the spent or declining fields of cotton or chillies, entirely without preparatory cultivation. Rarely

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"RUSTUM," age 2½ years.

is the clover sown on fallow land, and never, never is it manured. During the cold season *shaftal* is on almost every acre that is not bearing wheat or barley or some other *rabi* crop, or that is not occupied by ripe sugarcane. The total area of *shaftal* in the North-West Frontier Province must exceed 50,000 acres, and perhaps in all the world there is no part where clover occupies a larger proportion of the land, or is employed to better advantage than in the valley that leads to the Khyber. By what lucky turn of fortune did growers of sugarcane in Peshawar find that the cheapest, most profitable crops of cane may be produced by simply laying down setts in moist growing *shaftal?* It is easier to guess how they discovered that maize after *shaftal* yields bountifully. In the rotation of crops on irrigated land the Pathan's principle is simple and sound, and it is this, "Grow *shaftal* as often as possible without sacrificing more valuable crops." Having maize, wheat, barley, sugarcane, chillies, tobacco, pulses, etc., to select from, and with *shaftal* always to fall back on, zemindars in the Peshawar valley wisely refrain from following any hard and fast rotation, and they rarely indulge in a long fallow. It was not always thus, however. Thirty years ago, so say the older cultivators, *shaftal* was little known or at any rate very little grown in the Peshawar valley. Who then, that knows the North-West Frontier Province, dare say the cultivators are conservative? Here is one example of their willingness to adopt a new crop, that might shake the belief of those few doubters who still sadly hold that the cultivators will continue to "scratch the soil" and go on their own way indifferent to any improvements that are offered to them. It may here be mentioned that *Pounda* sugarcane is also a comparatively new crop in the Peshawar valley, and now the area annually planted exceeds 25,000 acres.

But this article is headed "Awankari Cattle at Peshawar." Well, the North-West Frontier Province cultivators could not keep many cattle if they had not *shaftal*. It is true they do not even now breed many good animals. They prefer to purchase old oxen from the Punjab and strengthen these by a liberal ration of *shaftal*.

The irrigated area of the Peshawar Agricultural Station is about 200 acres, and a considerable part of the land is intensively

cultivated. Manure for so large an area cannot be purchased in the neighbourhood, and it is not advisable to tempt the cultivators to sell their manure. To maintain the fertility of the soil and to keep the land free of weeds, *shaftal* and *berseem (Trifolium alexandrinum)* are therefore grown each year at the Agricultural Station to the extent of 20 or more acres. This large area is cut five or six times, or a portion of the crop is fed off by fat-tailed sheep. There is, in fact, so very much clover available between October and June that it was decided in the autumn of 1916 to start a small herd of cattle at the farm, and in October last 10 beautiful typical "Awankari" cows were procured from their home in the North Punjab. Nine of the animals were then in calf, and now each has a handsome calf at foot. Since their arrival at the farm no one of the herd has been sick or sorry, and almost without exception the young stock promise to be excellent, typical specimens fit for stud or inclusion in the Station herd book. "Awankari" cattle, although alien to the North-West Frontier Province, are valued above other breeds by the cultivators because they are hardy, handy, powerful and fast alike in the cart and in the plough, and, fortunately, they are also handsome in appearance. Their even black and white markings and free bold carriage appeal to the Pathans who appreciate beauty and courage in all animal life. The best specimens are reared in the homes of the Awans of the North Punjab who value male animals highly but neglect the cows. In the Peshawar market a pair of average good five-year old Awankari oxen cannot be purchased for less than Rs. 250 to Rs. 300, and this price is occasionally paid for a single bullock. As far as the writer knows there was not a pure-bred female of the breed in the Peshawar District until the cows arrived at the Agricultural Station last autumn. This may be due to the unfortunate fact that "Awankaris" are poor milkers, but perhaps there are other reasons why cows have not been imported to Peshawar, as several landlords have lately requested the Agricultural Officer to procure one or two good pure-bred cows for them. Since they arrived at the Agricultural Station the animals have been liberally fed and, with abundance of pure water and ample grazing by the banks of the Bara river, the herd has



Fig. 1. AWANKARIS ON THE BANKS OF THE BARA RIVER.

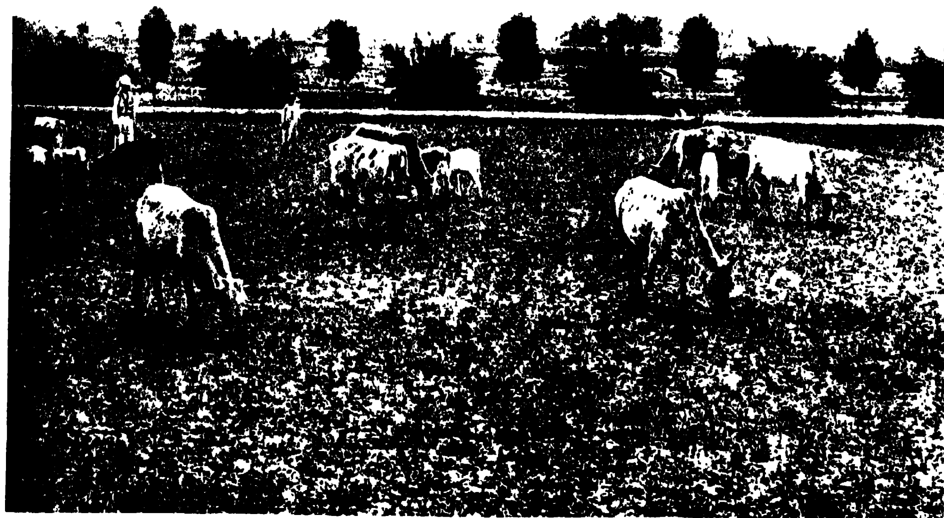


Fig. 2. AWANKARIS BUSY IN THE HOME PARK.

improved very much. Four of the cows are by no means poor milkers, so it is hoped that a herd of fair milkers may ultimately be established without sacrificing any of the more important qualities the breed now possesses. All who see Awankari cattle for the first time are impressed with the resemblance typical specimens bear to one another, in conformation, in markings, in the size and shape of their horns, and even in their carriage. Surely a breed that comes so true to type in the hands of the Awans must have a long interesting history.

The herd has certainly added greatly to the attractions of the Agricultural Station, and it is believed, now that cows have been introduced, that cultivators in the North-West Frontier Province will in time be persuaded to breed then own plough animals and incidentally to make still bettei use of their abundant supply of clover.

In the table of measurements given below the cows compare unfavourably with the station bull and bullocks in size and "bone." This is not surprising, for, as has already been stated, the male calves are generously treated whilst the females receive bare sustenance.

AWANKARI HERD

AT THE

PESHAWAR AGRICULTURAL STATION.

Cows.

Name	Age, years	Length (Inches)	Height (Inches)	Girth (Inches)	Shin (Inches)	Colour	Price Rs.	Calf at foot born	REMARKS
Shirina ...	4	48	45½	63	6	Black and white.	85	9-7-17	A big cow.
Badrai ...	7	49	47	61	6	do.	80	8-3-17	Rather coarse, calf large coarse.
Margiana ..	4	44	44	59	5¾	do.	74	14-2-17	A fair milker. Calf very beautiful.
Zarina ...	6	51	47	60	6	do.	90	20-8-16	A beautiful typical cow.
Hussaini ..	5	50	47	61	5¾	do.	92	4-5-17	Plate XLIII, fig. 2, a very typical animal.

AWANKARI HERD—*concld.*

Cows—*concld.*

Name	Age, years	Length	Height	Girth	Shin	Colour	Price Rs.	Calf at foot born	REMARKS
		Inches							
Sesame ..	4	50	49	62	6	Black and white.	100	12-2-17	A very poor milker. Calf good.
Mahbuba .	4	52	47	64	6	do.	100	19-3-17	A good milker. Calf handsome.
Niazbina .	3	50	47	60	5¾	do.	85	25-12-16	A fair milker. Calf excellent.
Laila ..	7	52	46¾	59	6	do.	85	1-5-17	A good milker. Calf good.
Rahai ...	8	48	47	62	6	do.	65	...	A fine typical cow.
BULL.									
Rustum (Plate XLI) ..	4	60	51	75	7	Black and White.	130 At age two years.	...	A handsome and very typical bull, in high favour with breeders.
BULLOCKS.									
......	6	54	52	68	7	Black and white.	140	...	A beautiful well-matched pair.
.....	6	57	52	69	6½	do.	140	...	

The handsome bull named Rustum (Plate XLI) was purchased as a two-year old for Rs. 130 only, and he is now stationed at the Agricultural Station, where he appears to be appreciated, as he has served over 30 local cows within the past four months. Plate XLII, fig. 1, is a pleasing view of some of the Station herd on their grazing ground by the banks of the Bara river which flows by the farm. In Plate XLII, fig. 2, the cows are busy in a field near their stable, and the beautiful Hussaini with her new born calf makes an excellent picture (Plate XLIII, fig. 2). The set of photographs, which were taken by Mr. Holmes of Peshawar, would not be complete without the inclusion of a typical bullock. The animal shown in Plate XLIII, fig. 1, is a great worker.

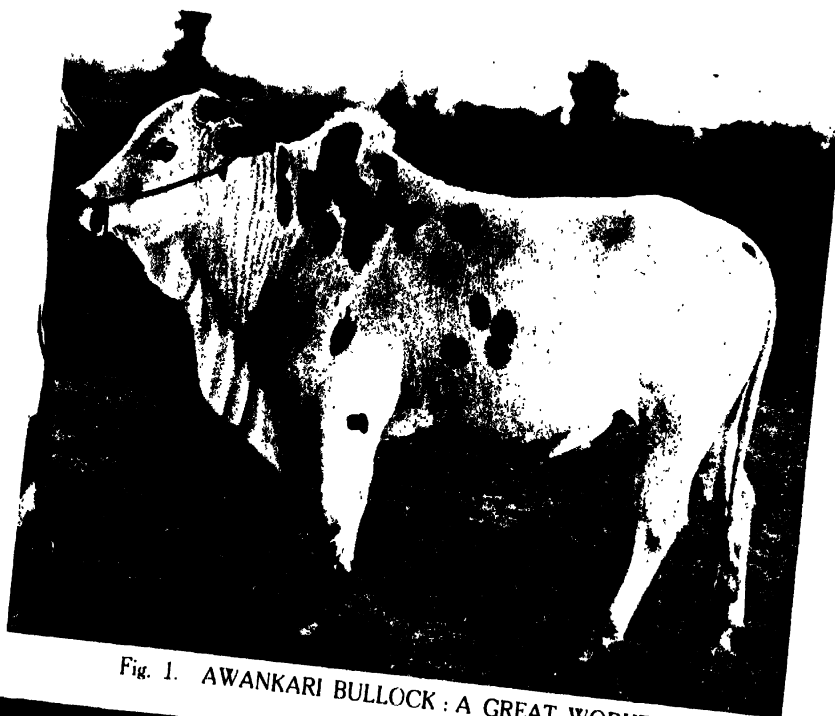


Fig. 1. AWANKARI BULLOCK : A GREAT WORKER.

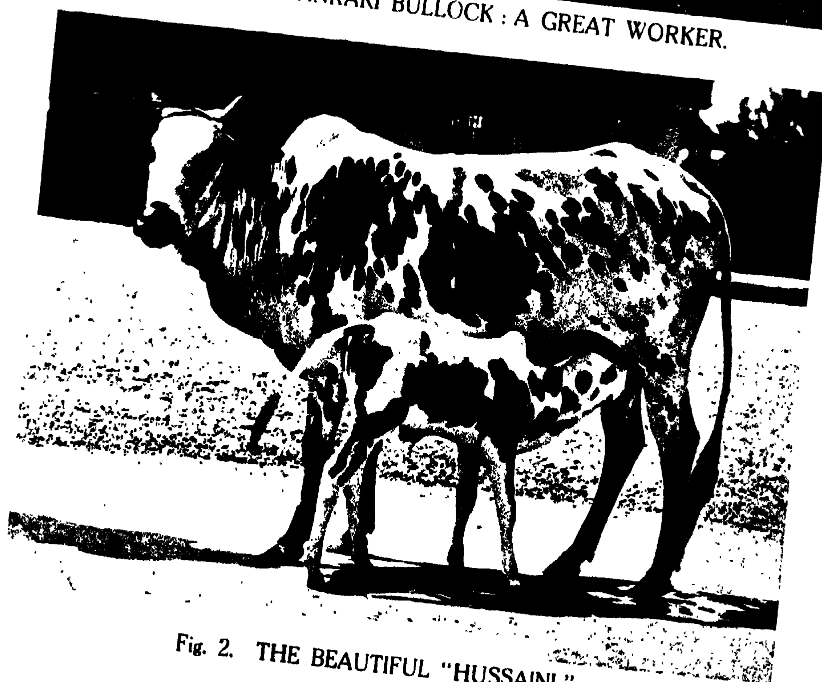


Fig. 2. THE BEAUTIFUL "HUSSAINI."

SURVEY AND CENSUS OF CATTLE IN BENGAL: A REVIEW.

A RECENT resolution of the Government of Bengal (dated the 16th May, 1917) reviews the report on Survey and Census of the Cattle of Bengal by Mr. J. R. Blackwood, formerly Director of Agriculture, Bengal. The report was the outcome of the instructions issued by the Government of India in 1911 that the detailed cattle survey throughout India should be preceded in each of the major provinces by a general preliminary survey of cattle on non-technical and economic lines. The report is particularly valuable in that previous to this enquiry no proper census of the cattle in Bengal had been taken, and Mr. Low writing in the *Agricultural Journal of India* in 1912 (vol. VII, pt. 4) on the question of the supply of agricultural cattle had to exclude Bengal, in dealing with the question of the relation of the number of cattle in India to the cropped area and cultivation, on account of the unreliability of its then existing figures. According to the figures compiled by Mr. Blackwood the total number of cattle in Bengal is 25,355,838 out of which 944,633 are buffaloes. The Government review points out that the number of human beings in Bengal is about 45½ millions, so that for every 100 human beings in Bengal there are 56 head of cattle as against 26 in the British Isles. It should, however, be borne in mind that the use of mechanical power which does away with animal power is more extensive in the British Isles than in this country and that much arable land had been converted there into pasture before this war.

Mr. Blackwood divides the breeds of cattle in Bengal into three classes.

1. Wild Cattle.
2. Hill Cattle.
3. The Cattle of the plains.

Of the wild cattle the *Gaur* or bison (*Gonæus Gourus*) is found in the Himalayan terai wherever there are heavy forests of large extent. It has never been domesticated nor has it been found to

cross with domestic cattle. Mr. Blackwood enters at some length into the question whether the Gayal or Mithun (*Gonæus Frontalis*) is a distinct species from the *Gaur* or bison and states that in his opinion the two species are distinct though closely allied.

As regards the hill cattle there are two distinct breeds, the *Siri* and the *Nepali*. The figures, as given in the census taken by the Deputy Commissioner of Darjeeling in 1912, bear out the observation of Mr. Quinlan that the *Nepali* breed is gradually ousting the *Siri* breed in the Darjeeling District.

In the plains of Bengal there is no tract in which the indigenous cattle are essentially different from those of any other tract, but there is a difference in size between the cattle of the eastern and those of the western districts. The former approximate in character to the cattle of Assam while the latter are more like Bihari cattle. In addition to their diminutive size Bengal cattle are distinguished from up-country breeds by the smallness of the dewlap and the sheath. Mr. Shearer,[1] late Imperial Agriculturist, was of the opinion that Bengal cattle are probably of the same stock originally as those of Bihar but have become diminutive because they have not been properly fed. The climate of Bengal, especially of the eastern part of the Province, is unfavourable to the development of strong and vigorous cattle. The most unfavourable period of the year is the rainy season when many tracts are flooded and cattle often find difficulty in getting even dry land to stand on. The deficiency of pasture and exercising ground, the shortage of suitable breeding bulls, the practice of castrating bulls at a late age, and the small proportion of the cow's yield which is generally allowed for feeding its calf are contributory causes.

The average indigenous bullock is a small, underfed, degenerate type of beast incapable of hard or prolonged work. Out of 8,087,872 bullocks 12·5 per cent. are imported while out of 7,110,634 cows the percentage of imported animals is only 3·7. The imported cattle come mainly from Bihar and the United Provinces, but Manipuri bullocks are imported into Tippera District. It is a striking fact that the proportion of imported bullocks to local bullocks is greatest

[1] *Agri. Journal of India*, vol. III, pt. 3, July 1908.

generally in the largest jute-growing areas and in those districts where large cattle fairs are held or in districts adjacent to them. The imported bullocks are stronger than local bullocks but their average life is much shorter. The milk yield of imported cows deteriorates when they are brought to Bengal, and the average annual yield of a good local cow, when a sufficient quantity of milk is given to the calf in the first three months, is less than three seers a day.

Mr. Blackwood ascribes the conditions obtaining in Bengal to economic causes. It is said that where the cultivators have limited needs and can get a good crop without deep-ploughing they are content to employ weak cattle. Hence it is that in Bengal where the individual holdings are small a tenant does not consider it worth while to keep and feed plough cattle of a quality superior to the lowest which is necessary for the work he has for them. While the continued pressure of population and the high prices obtained for food-crops have naturally led to a curtailment of the area available for grazing the most valuable fodder crops like *jowar* (*Andropogon Sorghum*) do not grow well in the districts of Eastern Bengal. People generally take it for granted that the welfare of cattle is bound up with the provision of grazing. But it is pointed out that an abundance of pasture land, if accompanied by a damp climate, is practically no safeguard against rapid deterioration. The experience of Assam is cited in support of this view. Moreover, apart from the very serious difficulties involved in any scheme for converting arable land into pasture, it is improbable that such a policy would have the results which are generally expected from it; the cattle would perhaps increase in number but they would soon become too numerous for the pasture to support. In fact plentiful grazing and good cattle are not necessarily found together; in the Champaran District of Bihar where good grazing is plentiful the cattle are, in the opinion of Dr. Voelcker[1], the worst of any in Bihar while in the Nasik District of Bombay even though there is no grazing the cattle are splendid. Climatic conditions and the provision of suitable grass or nutritious fodder all the year

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[1] Report on the Improvement of Indian Agriculture, p. 175.

round have much to do with the quality of cattle obtaining in a particular district.

It is reported that there are no professional breeders of cattle in Bengal except to a limited extent in the districts of Jalpaiguri and Malda. The creation of an industry of cattle-breeding on a large scale in the climatic conditions of Bengal as the result of an example set by Government cattle farms is problematical. What then is the remedy? It is obvious that in the scheme for the improvement of cattle, attention should be concentrated on the breeding of better bullocks and also better milch cows. However good the bulls may be, no good stock can be produced if the cows continue to be starved and neglected as they are now. Thus the provision of superior bulls and an improved system of cattle management including stall-feeding by the development of fodder crops and the provision of a sufficient quantity of milk to young calves are the principal lines to work upon under the existing conditions. Mr. Blackwood therefore recommends the multiplication of mixed dairy farms situated in the neighbourhood of large towns like the Government Farm at Rangpur opened in 1913, either under Government control or private management, for the development of superior milk-yielding cows, draught bullocks, and serving bulls and provision from these farms and from the Garo Hills of suitable bulls in selected areas, the bulls being kept in the immediate charge of *panchayats* under the general control of demonstrators of the Agricultural Department. Mixed dairy farms are to be used both for the supply of milk to towns and for cattle-breeding, thus reducing the cost of producing cattle. As to the class of animals to be employed, Mr. Blackwood's view is to improve the indigenous breed by selection and crossing with superior but nearly allied species, the attempts to acclimatize larger animals from other provinces having so far failed. He lays special emphasis on the point that the ideal type of animal to be produced is one which the ordinary cultivator of Bengal will be prepared to use and to feed. We quote here the concluding paragraphs from the Bengal Government's resolution on this subject.

"In his advice for the conduct of Government farms Mr. Blackwood lays stress on two points. First, he is strongly of opinion that

the basis of woık should be the indigenous cattle of the Province; and that the best indigenous cows, as judged by their milk yield, should be selected and crossed with superior bulls of a nearly allied species. He lays particular stress on his advice that the animal produced must be one which the ordinary cultivator of Bengal will be prepared to use and to feed. Secondly, he advises that the farms should have dairying and the production of fodder and other crops as their objects as well as cattle-breeding, his main object being that the farms shall be paying concerns and thus capable of extensive multiplication. The Rangpur Cattle Farm was opened in 1913, and Mr. Blackwood, as Director of Agriculture, conducted it on these lines for a period of three years: the Governor in Council has recently reviewed the progress which has been made at the farm and has decided that too much has been attempted. While he appreciates the force of Mr. Blackwood's arguments against endeavouring to introduce foreign stock unsuitable for the climate and conditions of Bengal, he is impıessed by the facts that the people in Bengal, who have the highest ideals about their plough-cattle, generally prefer imported animals and that the indigenous bullocks are rarely suitable for heavy cart work. Therefore it appears doubtful whether any substantial advance will be made without improving the local breeds by crossing. Mr. Blackwood asserts that the ideal type must be an animal which the ordinary cultivator of Bengal will be prepared to use and feed: the Governor in Council accepts this view with the modification involved by substituting the word 'superior' for 'ordinary.' When the use of a superior plough is demonstrated before a large number of cultivators the majority will say that the results are very satisfactory but are of no use to them because their bullocks could not draw the plough, but there are generally a few among them who have superior cattle, to whom the demonstration is of practical interest: the Governor in Council considers that the ideal type should be an animal which will appeal to the latter class of cultivator and that the best chance of arousing in the average cultivator a desire to improve his stock lies in the demonstration of results obtained by his neighbour who has higher ideals.

"The Governor in Council has therefore decided that work in the Rangpur Farm shall for the present be concentrated on experiment with the object of discovering the most suitable bull for crossing with indigenous cows, and that dairy farming must for the present be subsidiary to this object, while the demonstration of the financial success of mixed farming with a view to the multiplication of breeding farms must await the discovery of the bull which is most suitable for the country. With this object in view he has ordered that selected indigenous cows shall be used as the basis of the experiments and that there shall be two classes of bulls, local and imported, the latter being selected animals of the milking breed of Hansi cattle: there will thus be two distinct herds, the pure indigenous herd and the cross-bred herd. When the results obtained from either of these herds are found satisfactory the time will have come for schemes for multiplying the bulls on a large scale. As regards the milk produced on the farm the Governor in Council has given orders to ensure that the young calves shall not be deprived of a sufficient supply owing to a desire to show profits from dairying. Fodder will be grown on the farm for the use of the cattle and the study of questions relating to the improvement of fodder crops will be one of the primary objects of the farm."

The Report makes it quite clear that the average local cow is such a wretched specimen that the cultivator cannot afford to feed her better than he does. What he wants is a good milch cow which will not only rear a good calf but leave a substantial surplus of milk to her owner; such a cow he is prepared to pay for and to feed. The rising prices of milk and other dairy products have helped to raise the profits of dairying considerably, and it is becoming clear to *goalas* as well as to others that it is far more economical to have a few superior cattle rather than a large number of ill-fed, under-sized weaklings giving a poor yield of milk.

Let us hope that these attempts at systematic breeding of superior cattle in Bengal will be productive of satisfactory results in course of time.

Selected Articles.

AGRICULTURAL BANKS IN INDIA : A REJOINDER.*

BY

A. C. CHATTERJEE, I.C.S.,

Lately Registrar of Co-operative Societies, United Provinces.

In the first issue of the *Indian Journal of Economics* the place of honour was occupied by a long and powerful article from the pen of the Hon'ble Mr. D. E. Wacha, advocating the establishment of a large Agricultural Bank in each of the different provinces of India on the model of the Agricultural Bank of Egypt. The article has since been republished in the form of a pamphlet and has attracted considerable attention as is only natural with regard to a proposal made by such an acknowledged authority of financial standing and political experience as Mr. Wacha. So far as the article gives a historical retrospect of the measures adopted from time to time to ameliorate the indebtedness of the Indian peasant, it does not require any reply. The question whether the condition of the Indian cultivator has, on the whole, improved or deteriorated during the last half-century, a question which Mr. Wacha answers most decisively without quoting any facts of evidential value, is much too large to be debated within the space available in the pages of a quarterly magazine. But the condemnation, partly open and partly tacit, of the system of co-operative credit, for the development of which a large and growing body of non-official Indians have been labouring during the last ten years or more, humbly and unostentatiously and without desire for or expectation of any reward in the form of dividends or honours, should not be allowed to pass without demur.

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* Reprinted from the *Indian Journal of Economics*, vol. I, part IV, December 1916.

Moreover, the constructive proposal put forward by Mr. Wacha, *viz.*, the establishment of large provincial joint-stock banks on the Egyptian model to finance Indian agriculture, appears to be entirely unsuitable to Indian conditions. I had hoped, therefore, that the *Indian Journal of Economics* would publish in an early issue a rejoinder to Mr. Wacha's article. As no such reply has been announced so far, I venture to submit the following observations on the subject.

It may be presumed at the outset that the Hon'ble Mr. Wacha would wish his Agricultural Banks to be constituted entirely on the Egyptian model and not on a co-operative basis like the Provincial Co-operative Banks recently organized or in course of formation in the different Indian provinces. We may also take it that Mr. Wacha does not refer to an apex bank for the whole of India to co-ordinate and finance the provincial co-operative organizations as adumbrated in the final paragraph of the Report, published about a year ago, of the Committee on Co-operation presided over by Sir Edward Maclagan. It is, therefore, necessary to examine the constitution of the Egyptian Bank and to ascertain how far it has actually succeeded in solving the problem of agricultural credit in that country. We have also to study whether the conditions in Egypt, *viz.*, of agricultural tenure and security for credit are similar to those that prevail in the different parts of India, and also whether the system of advances and recoveries adopted by the Egyptian Bank can be suitably adopted in the environment with which we are concerned.

At pages 32 and 33 of his article Mr. Wacha has given a sketch of the constitution of the Agricultural Bank of Egypt. Briefly, the Bank has an authorized share capital, all issued, of £3,740,000 consisting of ordinary, cumulative 4 per cent. preference, and deferred shares. There is a Government guarantee of 3 per cent. The Bank has also an authorized debenture capital, all issued, of £6,570,000, in 3½ per cent. bonds, the bulk of which are directly guaranteed by the Egyptian Government. I am quoting from the published Report of the Bank for the year 1915-16. The Agricultural Bank works in close touch with the National Bank of Egypt which was its parent institution, and has a local directorate with a strong London committee. Loans are advanced in two forms. The first kind is

repayable in one instalment, practically in one year, although the maximum time allowed is fifteen months. These (styled A loans) are mostly for the recurring expenses of agriculture and are issued on pro-notes only, but are limited as a rule to three times the amount of the land tax payable to the Government. Advances of the second type (called B loans) are secured by first mortgage on land worth at least twice the sum lent, and repayable in annual instalments which may be extended to 20½ years. (*See* Annual Report for 1908, published in 1909, of Sir Eldon Gorst, His Majesty's Agent and Consul-General for Egypt, Parliamentary Publications, Egypt No. 1.) In 1912, the maximum of A loans was increased to £E200 and of B loans to £E1,000. (£975 Egyptian are equal to £1,000 sterling.) The rate of interest had been reduced by 1907 to 8 per cent., and appears to be the same still. In respect of either kind of loan, application has to be made on proper forms, obtainable from the *omdah* (or head official of the village) supported by a certificate of the tax-collector and handed in to the local agent of the Bank. After the loan is approved of by the proper Bank authority, payment is made whenever practicable in the presence of an English inspector as a protection to the borrower. The lists of sums to be recovered in principal and interest are prepared for each village separately by the Bank's agents and sent by the head office of the Bank to the Ministry of Finance which passes them on to the tax-collectors. The Government sends lists of recoveries effected to the Bank every month. A small commission is paid to the tax-collectors for their trouble.

Mr. Wacha has in his article referred with sarcasm to the optimistic reports issued every year by the special officer who administered the Deccan Agriculturists' Relief Act until a Government Commission appointed in 1913 condemned the operations of that Act. He predicts a similar nemesis to "the optimistic reports (issued by officers in charge) of the new-fangled (co-operative) credit societies." It is to be presumed that he has carefully studied the annual reports of the Directors of the Agricultural Bank of Egypt, for he quotes figures for the year ending 31st January, 1915. He has also provided copious quotations from the annual reports of the

Agent and Consul-General during the earlier stages of the Bank. For a fuller elucidation of the subject I am constrained to furnish a few more extracts from similar reports for later years. In the report for 1908, Sir Eldon Gorst mentioned that the amount of loans put out since the foundation of the Bank was £15,140,000 of which "A" loans were £2,110,000 and "B" loans £13,030,000. The repayments had been :—"A" loans, £2,018,000 and "B" loans, £4,622,000. In the report for 1909, the following interesting passage is to be found :—

"Owing to a variety of circumstances, the Bank's operations during the first few years were conducted under exceptionally favourable conditions and they were not put to a severe test until the end of 1907 when the great prosperity which the Egyptian peasantry had begun to look upon as permanent received a temporary set-back. Accurate information as to the purposes for which the loans are used has never been forthcoming, but there is little doubt that a large proportion of money borrowed was devoted to the purchase of land. Of the remainder, some was used to pay for agricultural improvements, while the balance must have been employed in settling old debts and in expenditure of a more or less unproductive nature. The Bank's operations would appear, therefore, to have resulted in an increase in the amount of the land held by the fellaheen, but the impression that the loans have contributed to augment the number of small owners is erroneous. The Bank does not lend to anyone not already possessed of land, so that it cannot create new individual holdings."

Sir Eldon Gorst then discusses the question whether, in view of the fact that the greater part of the loans were put out at a time when the value of land in Egypt was continually rising owing to the great increase in the price of cotton, the fellaheen have not bought such land at prices which have entailed too heavy a burden during the ensuing periods of lean years. After quoting the figures of the amounts collected and in arrears in each year between 1904 and 1909, he proceeds :—

"These figures cannot be called altogether satisfactory, and they would seem to indicate that some portion of the advances

has been expended unwisely or used for unproductive purposes. The loans now outstanding amount to £8,136,000 distributed over 238,000 (borrowers) and the practical difficulty of discriminating between the demands put forward is very great. Nevertheless, measures have been taken to ensure that, in future, there shall be more careful investigation into the situation of prospective borrowers and the purposes for which loans are required than has occasionally been the case heretofore. It is also hoped that it may be feasible to introduce a system of collective guarantors and to form co-operative village organizations with which the Bank could deal directly. The collective guarantee would, on the one hand, ensure the punctual repayment of the loans and on the other, secure that no advances were made except for remunerative objects."

Sir Eldon Gorst concludes the reference to the operations of the Bank with proposals for facilitating the recovery of debts through the courts, similar to proposals which co-operative workers in India have been pressing for some time past. In the report for 1910 (Egypt No. 1 of 1911), Sir Eldon Gorst has the following interesting observations on the working of the Agricultural Bank :—

" There appears to be little doubt that the fellah has accustomed himself during the past few years to a higher scale of living aided thereto by the increase in value of his crops and by the loans of the Agricultural Bank . . . . . and that it is only by the severest pressure of circumstances that he can be brought to recognize the necessity of fulfilling his obligations at the sacrifice of comfort. He is also realizing more fully that he can delay repayment of his debts to the Bank with temporary impunity. There is evidence also of a considerable amount of borrowing from the village money-lenders during the less favourable seasons of 1908 and 1909. When a fellah owes money both to the Agricultural Bank and to the money-lender, there is no doubt that the latter recovers his loans before the Bank.

" The assistance rendered by the Government to the Bank has not been confined to the collection of its instalments by the

tax-collectors. No efforts have been spared by the officials to bring home to defaulting debtors a sense of their obligations, and there is no doubt that, at all events in Lower Egypt, these efforts have had considerable effect on the returns.

"The results of the past few years have led the Bank to adopt a more cautious policy with regard to the out-put of new loans. Advances have been restricted or even entirely withheld in districts where there are large arrears. In some villages special inspection is made before a loan is granted. The purpose for which loans are required continues to be the object of enquiry before they are granted, though the value of this information is very limited."

In the report for 1911, which was the first issued by Lord Kitchener as Agent and Consul-General, there is no specific mention of the Agricultural Bank, but the following pertinent passage may be quoted :—

"The indebtedness of the fellah has always been a source of grave economic anxiety. It is hoped that the spread of education may teach him to be more careful in his monetary transactions and that an extension of savings banks to the villages will give him the means of practising thrift and enable him eventually to clear himself of debt."

Lord Kitchener did not refer to the Agricultural Bank in the reports for 1912 and 1913. Reports for 1914 and 1915 have not yet been issued or presented to Parliament. In the report for 1913 (Egypt No. 1 of 1914), the latest available and the last written by Lord Kitchener, will be found the following extremely interesting observations :—

"The introduction of a system of agricultural co-operation in the village life of the community has been for some time the subject of general discussion. The possibility of successfully working such a system in Egypt and the advantages to be obtained from it have been demonstrated by experiments in several villages throughout the country. The new Ministry of Agriculture will be able to supervise and assist the agricultural operations which the co-operative societies will undertake in the villages.

Undoubtedly the principal factor on which their success will depend will be the degree of facility with which they are able to obtain advances of money at cheap rates. Such rates can only be obtained by establishing syndicates on the legal basis of registered civil companies and by placing their finances under the supervision of the Finance Ministry. As soon as legislation on these lines has been enacted, we may hope to see a considerable development of the application of the co-operative principle to agricultural life in the villages."

I wish to apologise for the length of the quotations, but they will serve to show that the official mind in Egypt no longer sees in the Agricultural Bank a panacea for the manifold evils of agricultural indebtedness. Not only has the nemesis predicted by Mr. Wacha for the new-fangled credit societies of India already overtaken his pet institution, the Agricultural Bank of Egypt, but it is clear that the highest authorities in that country have for some years past been hoping to adopt the Indian system, despised by Mr. Wacha, for the betterment of the condition of the Egyptian peasant. The testimony of the latest reports of the Agent and Consul-General is singularly confirmed by the action of the Agricultural Bank itself to protect its own finances and operations.

The following instructive tables are extracted from the report of the Directors of the Bank for the year February 1915 to January 1916 :—

Arrears on annual instalments.

Year	Annuity due	Amount of annuity in arrears at end of year	Percentage of arrears to annuity
	£E	£E	
1909–10 ..	1,804,141	319,408	17·7
1910–11 ..	1,750,616	329,805	18·8
1911–12 ..	1,587,634	247,558	15·6
1912–13 ..	1,507,841	337,356	22·3
1913–14 ..	1,392,255	367,756	26·4
1914–15 ..	1,212,087	902,138	74·4
1915–16 ..	1,001,304	258,918	25·8
1916–17 ..	816,691	..	..

Collection of arrears.

Year	Arrears brought forward at beginning of year	Sums recovered during year	Percentage
	£E	£E	
1909–10 ..	296,141	198,663	67·0
1910–11 ..	416,887	244,110	58·5
1911–12 ..	502,582	234,420	46·6
1912–13 ..	515,720	199,742	38·7
1913–14 ..	653,334	316,263	48·4
1914–15 ..	704,977	212,569	30·1
1915–16 ..	1,394,546	444,278	31·9
1916–17 ..	1,209,186	..	..

DETAILS OF LOANS OUTSTANDING.

(Collated from the reports of the directors for the respective years.)

	"A" LOANS		"B" LOANS	
	No.	Amount	No.	Amount
31st January—		£E		£E
1910 ..	6,675	71,515	231,181	8,065,968
1911 ..	1,572	17,596	233,927	7,824,362
1912 ..	3,419	36,951	231,647	6,970,296
1913 ..	3,241	35,422	232,466	6,841,196
1914 ..	364	8,606	203,579	6,112,635
1915 ..	5	192	159,337	5,491,749
1916 ..	67	1,721	122,632	4,933,297

It is evident that the non-mortgage short loans (A) are now practically negligible, while the Bank is steadily contracting the volume of its long term mortgage loans also. The reasons for this procedure are partly described in the 1909 and 1910 reports of Sir Eldon Gorst which have been quoted above. But another and a very important circumstance has also affected the business of the Bank. In 1912, the Egyptian Government passed a measure improving the procedure for the realization of debts for which the Bank had been agitating for some years. But at the same time it enacted the Five-feddan Law, which by prohibiting distraint being levied on the agricultural property of cultivators consisting of five feddans or less (1 feddan = 1·038 acres), withdrew from all such

peasant proprietors the power which they had hitherto possessed of borrowing on the security of their land. From official figures quoted in the annual report of the Agricultural Bank for 1912-13, it would appear that out of a total number of 1,433,423 registered native landowners in Egypt in 1911, as many as 1,292,398 owned not more than five feddans. The Directors estimated that, out of the 235,000 clients then on the books of the Bank, the large majority were holders of five feddans or less and that the new law, failing the adoption of other measures, would gradually reduce the business of the Bank by about two-thirds. Representations were made by the Bank to the Government that its operations should be exempted from the restrictions of the new law, in view of the fact that the Bank was founded in 1902 at the request of the Government with the object of lending to the small cultivators on the security of their land. The Government refused to accede to these representations, but permitted the Bank to raise the maximum limits of the two classes of loans and agreed to a few other palliative measures. The Bank took powers to make advances to Agricultural Syndicates and to *grant collective loans to groups of cultivators*. But so far the business transacted in this manner appears to have been small. In 1914-15, about £20,000 was thus advanced and in 1915-16, about £6,000. The reason probably is that the Egyptian Government has not yet passed the special enabling legislation for co-operative societies referred to in Lord Kitchener's Report for 1913. At all events the Agricultural Bank finds itself unable to utilize its available capital in advances to cultivators—which was originally its sole object—and has been compelled, with special modification of its statutes, to invest large sums of money in its own debenture bonds, in Government securities, in shares of the Mortgage Company of Egypt, and in general mortgages.

The tables given above also indicate the growing difficulty the Bank is experiencing in collecting from its cultivator clients the current instalment that falls due every year as well as the arrears that are steadily accumulating. Another unsatisfactory feature of the work, at least from the general economic standpoint, is that the Bank is obliged every year to acquire by auction purchase a

large area of land belonging to its recalcitrant debtors. Although such areas are generally re-sold subsequently without pecuniary loss, land management is outside the ordinary purview of a bank's work and cannot but hamper its normal business.

We thus see that, notwithstanding all the initial advantages with which the Agricultural Bank of Egypt began operations, it encountered serious and almost insuperable difficulties directly the period of exceptional agricultural prosperity which synchronized with its foundation came to an end. The Bank had a Government guarantee for its capital. It lent money only to peasant proprietors who had tangible and valuable security to offer. Advances were made on the certificate of officials in charge of the land records. Recoveries were effected through the tax-collectors. From the language of Sir Eldon Gorst's Report, quoted above, it is clear that a good deal of official pressure was exerted to secure collections. In spite of all these favourable circumstances, the Bank was getting into difficulties when the Five-feddan Law and the removal of mortgage security compelled it to seek business in other channels, and to restrict its loans to cultivators only to transactions involving large sums or where a collective (or in other words co-operative) guarantee was available. There is no doubt that the Agricultural Bank has failed to solve the problem of agricultural indebtedness in Egypt.

Before passing on to the subject of the adaptability of the Egyptian model to Indian conditions, I may be permitted to point out that Mr. Wacha is inaccurate in stating that it had never been found necessary to utilize the guarantee given to the Bank by the Egyptian Government. Lord Cromer had also expressed a pious hope (Egypt No. 1 of 1904) that no occasion would arise for calling on the Government to make good a deficit. The necessity did arise in 1915 (*vide* the Directors' Report for 1914-15, p. 4), and the Egyptian Government had to pay £E11,652. It is true the circumstances were exceptional and the amount was repaid by the Bank from its profits in the following year (*vide* Directors' Report for 1915-16, p. 2; and Profit and Loss Account). It is also interesting to note that the 3½ per cent. guaranteed bonds of the Bank varied

in price in 1913 (*i.e.*, before the war), between 85 and 76½ while quotations for its ordinary £5 shares ranged during the same year between 5$\frac{31}{32}$ and 4$\frac{11}{16}$. The closing price on 31st December, 1915, was £3.*

We shall now briefly examine the question whether, even if the Agricultural Bank of Egypt had been as successful as Mr. Wacha portrays it to have been, its methods could be copied for the benefit of the Indian peasant. Mr. Wacha opines that "in all probability the reason why the Anglo-Indian bureaucracy, which has been actively connected with the co-operative credit movement, has looked askance at this most successful Agricultural Bank is owing to want of knowledge of the true history of the institution from the date of its inception." We have now seen what the true history is so far as it appears in the published records. It is also an open secret that, before the Indian Act of 1904 was passed, the Egyptian system had been studied, to some extent on the spot, by officials belonging to the Indian Government. Moreover, some years subsequently a very wealthy syndicate of European "capitalists and financiers of the highest monetary reputation" (to use Mr. Wacha's phrase again) is understood to have offered to establish a similar Bank in India. Happily, for reasons that are not known to me and are possibly not unconnected with the recent history of the Egyptian Bank, this proposal came to nothing. The Egyptian Bank was based on individual and mortgage credit. Such credit, it is true, is available in the ryotwari provinces of Madras and Bombay. How far it has proved a blessing or a curse to the Deccan peasant may be to a certain extent gauged from the introductory passages of Mr. Wacha's article. It suffices, however, to state that the cultivating tenant of Bengal, the United Provinces, the Punjab, Bihar, and the Central Provinces does not ordinarily enjoy the power to mortgage his land. On much the greater part of this area, practically all cultivation is carried on by tenants and not by land-holders. In the Punjab and in Bundelkhand (in the United Provinces), much of the land is cultivated by co-sharing proprietors,

* Johnson and Sanderson's Stock Exchange Investment Hand-book.

but the legislature has found it necessary in both these tracts to enact special Land Alienation Acts which seriously restrict the power to mortgage. It is not possible here to discuss the economic desirability of such legislation, but the present writer can affirm from intimate personal knowledge of Bundelkhand that the cultivating proprietors there are perfectly satisfied with the present law. The Government of Egypt has in the Five-feddan Law only copied the example of the Punjab and Bundelkhand. In any case the Egyptian system could not be adopted in the greater part of Northern India without a radical change in the law. How difficult it will be to effect such a modification of land tenures, operating as it will to the detriment of the immediate interests of land-holders, must be apparent to all acquainted with the history of tenancy legislation in Bengal, Oudh, and the old North-Western Provinces. For a recent manifestation in the same direction we may refer to the proceedings published by the United Provinces Government in 1915 of a Committee of the Legislative Council appointed to draft a new Tenancy Bill for the province of Agra. In provinces like Oudh where the vast bulk of tenants do not possess even a right of occupancy, it is absurd to suggest the establishment of an Agricultural Bank for the benefit of cultivators on the Egyptian model.

There is next the question of the system of advancing and recovering loans. In Egypt it is all done through the tax-collectors. I have no personal experience of the system of land revenue collection in the ryotwari provinces, but in Northern India the Government officials have to deal only with the proprietors, a body infinitely smaller than the large mass of cultivators who would borrow loans for agricultural purposes. There is at present no Government agency which can be utilized for the recovery of loans advanced to cultivating tenants. Any such agency to facilitate the operations of an agricultural bank will have to be created *ad hoc*. There will be the same trouble with regard to the recommendations from Government officials that are an essential feature of the Egyptian Bank when advancing loans. It is true that the existing agencies have to be employed in advancing and recovering *takavi* loans to

cultivating tenants. But those of us, who have had experience of the issue and recovery of large amounts in Government *takavi*, know how weak and inefficient the whole organization proves to be in actual practice. Any impartial and unprejudiced inquirer will soon find out whether a small cultivator prefers to take a *takavi* loan carrying 6¼ per cent. interest or a loan from a co-operative society carrying a much higher rate of interest. In the province of Bombay, the Central Co-operative Bank has had the advantage in a special tract of lending money on the recommendation of Government revenue officials. So far as I am aware the results have not been entirely satisfactory and neither the Bank nor the Government desire or contemplate the permanence or extension of the experiment. The utilization of Government tax-collectors for the security of loan applications and the recovery of advances on behalf of an agricultural bank will have all the manifold disadvantages of the present *takavi* system and none of its advantages. In practice also the agency which is now employed only for large improvement loans and in seasons of agricultural calamities and unemployment is sure to break down if utilized for the normal business of an agricultural bank.

It is not clear whether Mr. Wacha would postulate a Government guarantee of the capital of an agricultural bank as is the case in Egypt. If he does, one fails to see any justification for such a measure. The Government has the responsibility for recommending loans and also for collecting the outstandings. The cultivator will not receive the money at a lower rate of interest than he does under the *takavi* system. The Bank will not be able to obtain its capital even with a State guarantee at a lower rate than the Government does at present. The profit that the State now makes over its *takavi* transactions will provide dividends for the Bank shareholders. The system may be advantageous to the shareholders but is certainly not conducive to the well-being of the community in general.

We have now demonstrated that the principal features of the Agricultural Bank of Egypt cannot be copied with any advantage in similar banks in India. It has also been shown that the Egyptian

Bank has failed to answer the purpose for which it was founded, and that the administration has been driven by its experience to look to the alternative methods which have found favour in India. The difficult problem of agricultural indebtedness in India still remains, and everyone will sympathise with Mr. Wacha's desire to find a solution for the same. With State initiation and guidance many Indians are seeking a remedy for the present condition of affairs in the system of co-operative credit which has already proved eminently successful in every agricultural country in Europe. Mr. Wacha pronounces it to be a failure as far as India is concerned. The only argument he brings forward is that it is beyond the power and capacity of co-operative societies with their joint capital and credit ever to raise the immense sum of 250 millions sterling which he estimates to be the total amount of agricultural indebtedness in India. The figure that Mr. Wacha names does not frighten those of us who have actually worked for the movement. For the whole of India in 1914-15, the capital of agricultural societies alone exceeded 454 lakhs of rupees or a little over three millions sterling. The total capital of the co-operative movement was 897 lakhs of rupees, compared with only 24 lakhs in 1907. A cursory glance at the illustrative graph in the Indian blue-book entitled "Statements showing progress of the Co-operative Movement in India during the year 1914-15" will show how rapidly and continuously the capital has been rising. And all without any Government aid or guarantee. The small sum that was lent by the State to the societies at the inception of the movement is fast disappearing from the accounts owing to repayment. If the movement progresses at the present rate, one can have little doubt that the societies will be able to take over within a measurable period of time the entire financing of agriculture in India. Whether the cultivators will ever be able to carry on all their work with their own capital is a different matter. Agriculture is business like any other form of industry and must utilize credit if it is to flourish. The prime need of Indian agriculture is enhanced credit, and, so far, the co-operative system seems to be the only agency through which this need can be *safely and efficiently* satisfied.

Apart from the economic factors involved, workers in the co-operative field soon learn to appreciate the deep and wide educative influence of the movement. A statesman with a broad outlook, Mr. Wacha, will not fail to be impressed with the potential value of co-operative societies in training the masses of India for true self-government if only he will personally associate himself with the movement and devote to it a small fraction of his versatile energy.

LONDON,
September 1916.

CATTLE INSURANCE IN BURMA.*

BY

A. E. ENGLISH, I.C.S.,

Registrar of Co-operative Societies, Burma.

After some six years' experience in the introduction of co-operative credit into the various districts of Burma, it became clear that one of the chief causes of indebtedness was the loss of plough cattle by death from disease or accident. In accordance with the obvious fact that insurance providing for the replacement of cattle so lost, and for the evolution of a spirit of corporate responsibility for the tending of cattle, was preferable to the mere granting of credit to replace such dead beasts, efforts were made to discover a simple and suitable system of insurance of plough cattle suitable for Burma.

The matter was complicated, because Burma has a variety of climates, crops, crop seasons, cattle, and systems of cultivation and methods of cattle tending. Speaking broadly, there is the southern wet zone where rice is cultivated in the rains (June to November), where the rainfall varies from 80 to 150 inches and where it is never cold; then there is the northern wet zone comprising five hilly districts where the rainfall averages 80 inches and rice is the main crop, and where there is a distinct cold season; and between these there is the central dry zone with a rainfall varying from 15 to 40 inches, liable, where not irrigated, to serious droughts and having for two or three months a very high temperature (100 to 115° F.). In this dry area there is a large variety of crops. On the uplands

* Reprinted from the *International Review of Agricultural Economics, Rome,* February, 1917.

are grown cotton, sesamum, groundnut, *jowar* (*Andropogon Sorghum*), etc., in the rainy months (June to November); sugar-cane, rice, onions, and pulses are grown throughout the year under irrigation; and pulses, potatoes, chillies, and other miscellaneous crops are raised in alluvial land along the river in the dry weather (November to April).

In the north and south wet zones the buffalo was till recently the principal draught beast. In the Delta districts, however, the buffalo's susceptibility to rinderpest has brought about an ever extending use of bullocks, and there is now a large annual export of bullocks bred in the dry zone to Lower Burma for ploughing and carting purposes. In the northern wet zone, where soils are heavy and weeds strong and where cattle are also used for timber extraction, the buffalo remains in favour, but the village herds are still liable to terrible epidemics of rinderpest.

The systems of cattle tending differ widely in the wet and dry zones. In the southern wet zone the grazing ground system is the rule. Each village has an area, generally uncultivable, allotted to it for grazing purposes, and in this area the village cattle have to pick up a precarious living. In many cases these areas are, in the rains, seas of mud, covered with a trampled growth of coarse muddy grasses. They provide the best possible means for spreading infectious disease and the cattle that have to exist on them naturally have an excellent chance of dying from disease, starvation, or exposure. The mortality in such districts is very high and many cultivators regard four years as the working life of an imported beast. It is probable that a premium of 15 per cent. would not cover the risk in this part of the country. In the northern wet zone the area of "jungle" available for grazing is as a rule much larger and there is a certain amount of segregation during grazing. Violent epidemics are unusual except from the unusually infectious disease of rinderpest. These jungles, however, contain a danger from which the southern grazing ground is free and that is wild cattle—bison, deer, and pigs from which anthrax and other diseases are undoubtedly communicated to tame cattle. If insurance be ever extended to the northern districts, a high rate of premium will be necessary. In

the dry zone districts the custom is that draught cattle, which are almost entirely bullocks, are stall-fed, while cows and calves are grazed in herds in scrub jungle near the villages. The stall-fed draught cattle are carefully fed and housed and seldom suffer from epidemics. The breeding herds are tended with much less care and suffer from scanty fare, bad housing, and dirty pens. In a season of drought the cows and calves die in large numbers. Disease also kills them off in quantities. Except in a few very restricted areas cows are not used by the Burmese for milking purposes, and it is somewhat surprising that with the treatment they get they produce such good draught stock.

In view of the above conditions it was obvious that the first experiments in insurance must be restricted to draught cattle, and to such cattle only in selected dry zone districts where the stall-feeding and careful tending of such animals was the rule. The Registrar of Co-operative Societies suggested the adoption of a system whereby animals would be valued half-yearly and insured for a half-year at a time, and it was decided to limit the experiment in the first instance to five adjacent districts, *i.e.*, Mandalay, Shwebo, Sagaing, Kyaukse, and Meiktila, in all of which such statistics as were available showed that violent epidemics of infectious disease among draught cattle were unusual.

Co-operative cattle insurance was discussed at the Provincial Agricultural and Co-operative Conference held at Mandalay in 1911, after six mutual co-operative cattle insurance societies had been formed, and it was resolved that insurance was desirable and feasible and that the scheme should be proceeded with. In the period between July 1911 and June 1912, seventeen, and in the year 1912-1913, thirty-six societies were formed. It then became evident that in the early years, to render certain payment of part at any rate of the indemnity, reinsurance was essential. It also appeared that insurance would not become really popular unless deaths from rinderpest were covered.

The whole subject was again discussed at the Agricultural and Co-operative Conference held at Mandalay in August 1913: and in a meeting which over 300 chairmen of agricultural credit societies

attended, it was then resolved that the premium rate should be raised from ~~3⅛ per cent. to 5~~ per cent. per annum, and that rinderpest deaths should be covered ; that a central reinsurance society was essential ; and that to eliminate the risk of fraud, membership of cattle insurance societies should be restricted to persons who are members of co-operative credit societies.

The sanction of the Secretary of State for India to the grant, by way of an interest-free loan, to the central reinsurance society, of assistance to enable it to meet indemnities in the early years was received early in 1915. The amount to be drawn in any one year is not to exceed Rs. 25,000 and repayments are to be made from the sixth year onwards from the central society's reserve fund.

Cattle insurance was again discussed at the Agricultural and Co-operative Conference held at Mandalay in August 1915 ; and it was resolved that the central reinsurance society should be formed, that in the five districts to which operations were at present to be confined every credit society should form an annexed cattle insurance society, and that for purposes of supervision a cattle insurance society should be admitted into the Union to which the credit society, to which it was annexed, belonged.

The Upper Burma Central Co-operative Cattle Reinsurance Society, Limited, was registered in August 1915. The membership consists of some fifteen honorary members—persons interested in co-operative and agricultural improvement—and of affiliated village cattle insurance societies. It receives half the premia paid to societies by members and insures half the risk undertaken by such societies. Indemnities due are paid by the manager on receipt of a cattle death report giving full details. It is managed by a general meeting, committee, and a manager. For the present the Registrar is acting as honorary manager. To safeguard the interests of Government, a government representative is a member of the general meeting and has five votes. It has a general fund, consisting of the current year's premium income, and a reserve fund consisting of the net proceeds of past years. The latter fund is banked with the National Bank of India and the general fund is kept in the Upper Burma Central Co-operative Bank. Societies

submit to the manager of the central society half-yearly statements showing the names of members and number, descriptions and value of cattle insured.

The by-laws of the village mutual cattle insurance societies are based on those used by French mutual societies. There are the usual exceptions of deaths from war, theft, etc., and societies do not pay indemnities where the sanitary regulations as to contagious disease have been broken. Membership is restricted. Valuations are made half-yearly by three experts appointed yearly by the general meeting. Substitution is permitted if values are equal. The premium rate is 5 per cent. per annum payable half-yearly in March and September. Funds are deposited with the local credit society at call. Deaths have to be vouched for by the experts and the society only pays two-thirds of the value insured. The skin and flesh belong to the society which sells them if saleable. Hence the owner stands to get two-thirds of the value insured, whether his animal dies of a contagious or non-contagious disease. Societies are managed by a general meeting and a committee.

Pending the formation of the central reinsurance society, the formation of village societies was restricted, and in the period July 1914 to June 1915 only seven such societies were registered. In the year July 1915 to June 1916, 247 societies have been registered and a further considerable increase is expected in the coming year. Of the 305 village societies in existence on 30th June, 1916, about a hundred had not yet become affiliated to the central society. The bulk of the new societies registered only started business in March or April 1916, and results cannot therefore be appreciated till October next at the earliest.

Judging by the steady accumulations of funds by those societies which have been working for several years, and in view of the fact that only two-thirds of the value is paid in indemnity, there is ground for believing that the 5 per cent. rate of premium is unnecessarily high and somewhat likely to hinder the progress of insurance. Burma has, however, except in the northern wet zone, enjoyed a remarkable measure of immunity from rinderpest in the last ten years. As it is yet too early to say that this immunity is due to the

improvement in veterinary control, and not rather to good fortune and disease cycles, it is perhaps better to err on the safe side in the matter of the premium rate.

Many of the villages in which cattle insurance societies are formed are in tracts only partially served by the Post Office and there is consequently difficulty both in remitting premia to the central society and in the payment of indemnities. Such difficulties, of course, check expansion but they will decrease with time.

In three areas during the year ending 30th June, 1916, epidemic disease—anthrax—appeared and accounted for mortality above the average.

There is every indication that the adoption of co-operative cattle insurance in these five districts where co-operative credit is already well established will promote better protection of cattle against disease, better relations with the Veterinary Department, and a decrease in mortality.

The statements given below show results to 30th June, 1916. It has not been necessary to draw upon the government guarantee loan.

Cattle are at present often undervalued: they average about Rs. 30 per head whereas a truer average would be Rs. 40. The proceeds of skin and flesh have exceeded expectations.

The societies are audited, along with the agricultural credit societies to which they are annexed, by the staffs of society-paid and government auditors, supervision being done by the inspectors maintained by unions of credit societies.

It is yet early to gauge results or to prophesy, but it may be said that the principles of insurance appeal to the Burman and that in the districts where a commencement has been made the co-operative idea has taken firm hold. Thus in the Kyaukse District there is one agricultural co-operative society (credit) for every 1,050 acres of cultivated land, while, in addition to co-operative credit, considerable progress with co-operative production and sale has been made in the districts of Mandalay, Sagaing, and Shwebo. If the high premium rate do not act as a deterrent, and if minor difficulties connected with remittance can be eliminated, there is no reason

apparent why co-operative insurance of cattle should not become firmly and widely established.

I. Operations of Cattle Insurance Societies in Burma.

On 30th June, 1916		Amount of risk insured on 30-6-16	Premia collected during the year	Number of animals		Claims paid during year	Cost of management during year	Funds at end of year	Amount of risk re-insured	Amount of premia for reinsurance
Societies	Members			Insured on 30-6-16	Lost during year					
		Rs.	Rs.			Rs.	Rs.	Rs.	Rs.	Rs.
305	5,045	2,87,051	9,737	7,929	75	685	219	10,671	113,050	4,022

II. Operations of the Upper Burma Central Cattle Insurance Society.

Number of affiliated societies	Proportion of risk affiliated societies reinsured	Amount of risk reinsured	Premia collected during year to 30-6-16	Number of animals covered by affiliated societies		Claims paid to affiliated societies	Cost of management	Funds in hand at end of year 30-6-1916	
				Insured	Lost			General Fund	Reserve Fund
		Rs.	Rs.			Rs.	Rs.	Rs.	Rs.
305	½	1,13,050	4,022	6,209	37	247	148	2,113	1,513

IMPROVEMENTS IN BACTERIOLOGICAL MEDIA.*

I.—A NEW AND EFFICIENT SUBSTITUTE FOR "NUTROSE."

BY

R. L. MACKENZIE WALLIS, TEMPORARY LIEUTENANT, R.A.M.C.,
Chemical Pathologist, St. Bartholomew's Hospital, London.

I. INTRODUCTION.

THE present communication deals with an investigation carried out with the object of preparing an efficient substitute for the patent German food-stuff known as "Nutrose." This investigation represents one phase of an extended research into the question of improvements and standardization of media used in bacteriology, but owing to the successful results so far obtained with this substitute it has been considered advisable to embody them in a separate communication. The German nutrose is sold in the form of a white powder, and is said to be soluble in water and to possess highly nutritive properties. Previous to the wai this preparation had a well-known scientific application as an important constituent of bacteriological media, more particularly Conradi-Drigalski and Nasgar. Reference to almost any text-book on bacteriology or dietetics reveals the statement that this nutrose consists of 'casein combined with an alkali (sodium).' Chemical analysis, however, indicates that the composition is not as described, and further it can be shown that an alkaline compound of casein is of no value as a substitute for nutrose in the media above mentioned. In the present communication I hope to be able to demonstrate that my new compound is a far more efficacious substitute for the German product, and has the advantage of possessing a higher nutritive value, combined with

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remarkable cheapness. Further, the use of ingredients obtained entirely from Indian sources renders this preparation of value as a food-stuff, apart from its use for scientific purposes. The dietary of the native is rich in carbohydrate, but poor in protein, and it is hoped that this preparation may prove of utility in providing a cheap source of additional protein nitrogen.

II. The Chemical Composition of Nutrose.

My attention was first called to nutrose whilst investigating a number of artificial food-products, which were said to have a beneficial effect in the treatment of glycosuria and diabetes mellitus. The preparation made by Messrs. Meister, Lucius Brunning & Co., yielded results which were quite contrary to those hitherto recorded as representing its constitution, as will be seen by reference to the following analysis :—

	Water per cent.	Protein per cent.	Fat per cent.	Carbohydrate per cent.	Acid per cent.
Nutrose ...	6·8	15·9	10·3	66·0	1·0

If the text-books were correct and nutrose consisted of casein combined with a sodium salt, it should give a protein figure of about 90 per cent., and thus possess a very high nutritive value. We see, however, that it contains only 15·9 per cent. of protein, and of this very little is actually casein, the greater bulk consisting of vegetable proteins of the nature of globulin. Now nutrose has always been classed amongst the dry milk products, of which a great variety are known. The ordinary dried milk or casein is prepared by the Protene Company, and placed on the market as " Protene flour " ; casein combined with ammonia is sold as " Eucasein " ; casein with soda as " Nutrose " ; casein with potassium gives " Plasmon " ; whilst " Sanose " is said to contain 80 per cent. of casein and 20 per cent. of egg albumen. Of other dried milk preparations, we have " Sanatogen " consisting of casein and 5 per cent. sodium glycero-phosphate. It is not the purpose of this article to embody an analysis of the various artificial products of casein, but simply to point out the fact that a chemical is usually added to render the casein soluble in water. Having regard to this fact it was not a difficult process

to ascertain the exact nature of nutrose. It contains casein and a sodium salt together with flour from certain cereals, and vegetable proteins from some other source. One of these vegetable proteins (presumably a legume) is undoubtedly a globulin rich in sulphur, which has hitherto not been described. From the chemical analysis, particularly the presence of this vegetable globulin and fat, it was concluded that nutrose contains pea-nut flour in quantity, and that this constituent is the most important factor in determining the properties of nutrose. Now pea-nut flour is very insoluble in water, and it seemed at first sight that there was some discrepancy. Casein is also insoluble in water, so that we have two insoluble constituents to deal with. Repeated experiments have, however, shown that the addition of sodium carbonate has a profound influence on the solubility of these two substances. In the first place, the sodium carbonate takes up the casein into solution, and the pea-nut flour goes into solution with it when the mixture is warmed. A striking feature of this behaviour is that only a relatively small quantity of sodium carbonate is required, *viz.*, a strength of 1 per cent. The resulting mixture is identical in reaction, and does not possess a bitter taste. It has been found preferable to add the mixture of casein, pea-nut flour, and sodium carbonate, directly to warm water with thorough stirring. The solution so obtained is very slightly opalescent, the only insoluble portion being the small quantity of fat present in the pea-nut flour. The exact explanation of this unusual phenomenon is not at present forthcoming. Another feature of the mixture is that it prevents the coagulation of the ascitic fluid used in the preparation of the Nasgar medium. We have then in nutrose a mixture possessing peculiar properties which render it highly adaptable for the preparation of bacteriological media and food-stuffs.

III. The Composition of the Pea-nut with especial reference to the Protein Content.

Arachis hypogœa, the pea-nut, earth-nut, ground-nut, or monkey-nut is a leguminous creeping plant indigenous to India, the coasts of Africa, and South America. Although the fruit resembles a nut

in that it contains fat, it is really a legume. After flowering the stalk bends over and enters the soil, where the seeds grow and mature. The seeds are contained in paper-like pods or husks, and there are usually two, but in some varieties four seeds in each pod. The nuts are shelled and the red inner skin separated as completely as possible from the true kernel. The kernel on being pressed yields about 45 per cent. of arachis oil, which in India is known as *katchung* oil, and is used as a substitute for olive oil. The crude oil fraction is applied in the manufacture of soaps. After expressing the oil the press cake left behind is sold as cattle food and is much valued as such, not only on account of its cheapness, but also for its high nutritive value and ready digestibility. In view of the large demand for arachis oil in the French soap industry large quantities of pea-nut found their way to Europe before the war. Hitherto the cake has not been recognized as a valuable food-product, but it will be seen later in this paper that when mixed with other cereals it has an extensive application. The average composition of the pea-nut is as follows :—

	Grammes per cent.
Water	14·6—12·8
Arachis oil	38 —50
Proteins	26 —31
Carbohydrates	5 —19
Fibre	1·1— 4·1
Ash	1·6— 3·0

In India the true kernel has the following composition :—

	Grammes per cent.
Water	7·5
Protein	27·5
Fat	44·5
Carbohydrates	15·7
Fibre	2·2
Ash	2·5

On expressing the arachis oil and exposing the resulting cake to the air and sun for some time, the pea-nut meal has the following composition :—

	Grammes per cent.
Water	9·8
Protein	44 5
Fat	9·2
Carbohydrates	23·8
Fibre	5·2
Ash	7·5

This cake therefore appears to be rich in protein, but relatively poor in carbohydrates. Further, this protein content seems to be remarkably constant, and analyses of various dried preparations of pea-nut flour give a protein content of 42 to 45 grammes per cent. These figures are somewhat lower than that found by Ritthausen in his analysis of pea-nut flour, *viz.*, 56 grammes per cent. The pea-nut flour analyses are sufficient to indicate that we are dealing with a product of vegetable origin, which contains a markedly high protein content, and accounts for its utility as a cattle food.

Not only do we find this flour of value on account of its nitrogen content, but there is evidence to show that it contains an active chemical principle of the nature of a "vitamine." Although much work has been done in an endeavour to prove the existence of such a substance in various natural products, so far the active principle or vitamine has defied all attempts at isolation. The small quantity of nutrose required in the preparation of bacteriological media, compared with its marked beneficial effect on the growth of organisms, leads one to suppose that it acts in virtue of the vitamine-yielding element, and not by reason of the added protein. That protein itself is not responsible for the effects produced is shown by the absence of this effect when casein alone is used. Dried casein, as far as we know, contains no vitamine, that present originally in the milk having been destroyed by subsequent treatment. The only other constituent in the new nutrose, which exerts this action, is therefore the pea-nut flour. From *à priori* considerations it appeared that the vitamine fraction was associated with the proteins in the pea-nut. It was therefore necessary to isolate the proteins of the pea-nut and determine their properties in this respect.

For the preparation of the proteins from pea-nut flour, with a view to deciding their nature and chemical properties, a perfectly dry sample of the cake was obtained. The brown skin had been carefully removed from the kernel, and the oil expressed by means of the oil press at the Medical Stores, Bombay. For the supply of this pea-nut cake I am indebted to Lieutenant-Colonel Swinton, I.M.S.

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[1] Ritthausen. *See* Osborne: *Vegetable Proteins*, Longmans, Green & Co.

The resulting cake was thoroughly dried by exposure to the air and sun, and afterwards pounded in a mortar to a fine mealy consistence. The dried meal was then shaken up with ether to remove the remaining fat, and the ethereal extract separated. The residue on being dried appeared as a fine white powder, and this was used for the isolation of the proteins. This white residue was ground up into a thick paste with a ten per cent. solution of sodium chloride, and the extract, after standing some time, separated by filtration through muslin, and subsequently through finely divided filter paper. A slightly greenish yellow opalescent filtrate resulted. The extract was now treated with five times its volume of distilled water heated to 50° to 60°C. The globulin present was at once precipitated on the addition of the warm distilled water giving finally only a very slight turbidity. On warming the solution the turbidity was markedly diminished, but did not disappear completely. This turbidity was found to be due to the presence of a small quantity of coagulable protein, presumably albumen. Small quantities of albumens have been described as occurring in a variety of cereals,[1] but usually in too small a quantity to admit of complete examination. On allowing the solution to cool slowly, the globulin separated out in the form of well-developed spheroidal crystals, the globulin was separated from the supernatant fluid and thoroughly shaken with distilled water. A fine milky suspension resulted, which defied all efforts at separation. Filtration through filter paper, asbestos, and kieselguhr had no effect in removing the opalescence. This method of separating the globulin from pea-nut is thus open to certain objections, and so was discarded in favour of another method. This consisted in throwing out the globulin from the diluted saline extract by passing carbon dioxide to saturation, and allowing to stand for several hours. The globulins in this case separated as a well-marked white precipitate. Experiments are now in progress to determine what part this crystalline globulin plays in the use of the pea-nut flour for bacteriological media. The globulin is also being subjected to tryptic digestion with a view to forming a new

[1] Osborne : *Vegetable Proteins.*

medium for the culture of various micro-organisms. Such a medium would not only be valuable on account of its cheapness, but also would overcome many caste prejudices at present prevailing in India.

This globulin, when mixed with casein and sodium carbonate, forms a mixture which is completely soluble in water, and hence is eminently suitable for mixture with agar to make up the well-known Nasgar medium.

IV. The New Substitute for Nutrose.

Since it was found that pea-nut meal entered largely into the composition of the German product nutrose, it was evident that it was quite possible to make up an efficient substitute by adding casein and sodium carbonate to it. Referring to the composition of nutrose as given above, it will be seen that it contains a large quantity of starch, and this is presumably due to the addition of other cereals to make it approach more closely to an ideal food.

For bacteriological purposes such a large quantity of starch is of course undesirable, so that these cereals were omitted from the new compound. The addition of the casein on the other hand not only improves the degree of subdivision of the resulting product, but also helps to render it quite dry, and consequently protects it from decomposition. As will be seen from the experiments recorded above, the casein in the presence of sodium carbonate renders the whole preparation much more soluble than the original German product. The final compound therefore is made up as follows :—

Pea-nut flour	94 parts
Casein	5 parts
Sodium carbonate	1 part

The final product consists of a very finely divided white powder with a sweet taste and a neutral reaction. This powder when stirred into hot water goes into solution with only a faint opalescence, and this opalescence is due to the fat which still remains in the pea-nut flour.

V. The Preparation of Media for Bacteriological Purposes and the Results obtained with its use.

The medium known as Conradi-Drigalski contains 1 per cent. nutrose, and is much used for the isolation of the colontyphoid group of organisms.. Samples of this medium were used for plating out cultures of typhoid and paratyphoid A and B from the stools of suspected carriers. The patients were all in the wards of the Enteric Depôt, Parel, convalescing from these infections. The results so obtained were compared with those with the new nutrose media. In every case the differences were most striking. Not only did the typhoid and paratyphoid colonies appear more luxuriant, but they were individually much larger, so much so that it was at first sight difficult to believe that they were actually the organisms in question. Any doubts on this point were at once set at rest by agglutination tests. The new medium has now been in use for some time and has fully acted up to all expectations. Of the medium itself no fault can be found, it being perfectly clear and stable. Comparative experiments are in progress to ascertain the value of this new mixture for the preparation of Nasgar for the isolation of the meningococcus, and also to supplement various other media so frequently used in bacteriological work.

VI. The Use of the New Nutrose as a Food-Stuff.

From the analysis recorded above, it seemed probable that such a highly nutritive mixture would be a valuable adjunct to various cereals in the preparation of a flour for breadmaking. It has long been recognized that pea-nut cake is a most useful food for cattle, combining, as it does, a high degree ot nutriment, together with easy digestibility. It has further the advantage of cheapness, in that it is a waste product at the present time, the much more valuable arachis oil being sought for chiefly as a substitute for olive oil and for soap making. For many years pea-nut flour has been recommended for making diabetic bread, and has many advantages to recommend it. Bread made with this flour, casein, and white of egg is quite palatable, and contains only a very small quantity of starch. It is in every way preferable to the many diabetic breads

placed on the market, and has the advantage of being very much cheaper. This bread may be made up in the following way in the household kitchen. The pea-nuts are first dried and their inner brown skin peeled off. The white kernels can now be ground up either in a nut mill, pestle and mortar, or grinding stone, and pea-nut flour thus obtained. It is, however, preferable to use the pea-nut flour obtained by grinding up the pea-nut cake after the oil has been expressed not only on account of the fact that a dry mealy flour is obtained, but also owing to its cheapness. Casein can be easily obtained in the market as a fine white powder, or we may use the new preparation direct. The ingredients of the diabetic bread are :—

Nutrose	10 ounces
Salt	A trace
White of egg	From eight eggs

The whites of eggs are first beaten up into a fine froth with an ordinary whisk, and the other ingredients slowly added with constant stirring. The mixture is placed in a baking tin and baked in an oven in the usual manner.

Such a bread possesses a sweet taste, can be easily manipulated, and is well tolerated by the patient. In view of the necessity of conserving our resources in war time, and also of rendering bread more nutritious, this new preparation is strongly recommended. It is possible that the bread so made will at the same time approach more closely to the ideal food in that it supplies certain protein constituents which are lacking in ordinary white bread. We have seen above how potent this preparation is in supplying bacteriological media with just those elements which are essential for the life and growth of the lower organisms, in other words the supply of vitamine.

Experiments based on these principles are now in progress, and in the second part of this article I hope to be able to report on the results obtained. Various mixtures of wheat flour and nutrose are being prepared, and the resulting bread subjected to analysis and feeding experiments. The question of preserving vitamine properties of the new nutrose is also receiving attention.

VII. Summary and Conclusions.

The results described in this paper demonstrate the value of the new nutrose as a constituent of certain bacteriological media. The fact that this preparation consists of substances obtained in India renders it of more than passing interest. In the new nutrose we have a product possessing properties of unusual nature, which open up a wide field for future investigation. It possesses, first and foremost, a constituent of the nature of a vitamine, and its value in bacteriology appears to be due entirely to this vitamine-yielding property. Another feature is its ready solubility in water, thus rendering it peculiarly adaptable for making up transparent media. Media made with this preparation have answered all the necessary tests, and the results have exceeded all expectations. There is reason to believe that the vitamine fraction is associated with the globulin in the pea-nut, and therefore it may be possible to further elaborate the preparation with a view to economy in material, combined with greater efficiency. The globulin in the pea-nut appears also to possess a high nutrient value, quite apart from the presence of a vitamine. In view of this fact the new preparation has been used as a food-stuff with satisfactory results. This is especially encouraging as we are dealing with a product which previously has not received much attention. The pea-nut cake has simply been regarded as a waste product, and used as cattle food in want of any other commercial application. The pea-nut grows in large quantities in India, and is of great industrial importance. The arachis oil is particularly valuable as a substitute for olive oil and the resulting cake combines a higher degree of solubility with an increased nutritive value. Future experience will decide whether this preparation will have a still wider application in conserving our supply of wheat flour, besides its present application for the making of diabetic bread and as a food for invalids.

Conclusions.

(1) A new and efficient substitute for nutrose has been prepared from substances obtained in India, *viz.*, casein, pea-nut flour, and sodium carbonate.

(2) This preparation combines ready solubility in water, with a high protein content, and consequently is of great nutritive value.

(3) This preparation when used for making the Conradi-Drigalski medium gives a transparent medium, on which the typhoid-coli group of organisms grows with marked luxuriance.

(4) The property of stimulating the growth of organisms appears to be due to the presence of a vitamine associated with the globulin contained in the pea-nut flour.

(5) In view of the high protein content, and relatively small amount of carbohydrate present, this preparation is particularly useful for making bread for diabetic patients, and also for admixture with ordinary flour.

(6) The new preparation combines the properties of a highly nutritive food-stuff, containing a vitamine, and extreme cheapness.

NOTE.—Since this work was completed my attention was called to an article by Carl O. Johns and D. Breese Jones in the *Journal of Biological Chemistry*, Vol. XXVIII, No. 1, December 1916, entitled "The proteins of the pea-nut *Arachis hypogæa* 1. The globulins Arachin and Conarachin." The authors have come to the following conclusions as a result of their investigations :—

"1. Two globulins have been isolated from the pea-nut. These have been named arachin and conarachin.

2. Arachin contains 0·4 and conarachin 1·09 per cent. of sulphur.

3. Arachin gave 4·96 and conarachin 6·55 per cent. of basic nitrogen, the latter being the highest percentage of basic nitrogen recorded for any seed protein.

4. From the results that we have obtained, it seems probable that pea-nut press cake will prove to be highly effective in supplementing food products made from cereals and other seeds, whose proteins are deficient in basic amino acids. Feeding experiments are already in progress to determine the nutritive value of combinations of pea-nut proteins with other proteins obtained from the more extensively used seeds."

These results are of particular interest since the writers have independently confirmed the value of pea-nut cake as a food-stuff. They have gone further in isolating two globulins from the pea-nut, differing markedly in composition. Experiments are now in progress to determine whether these two globulins exist in the Indian pea-nut. I did not see this paper until 8th March, 1917, when my work had already been completed for publication.

REPORT ON HUMOGEN.*

BY

E. J. RUSSELL, D.Sc.,
Director of the Rothamsted Experimental Station.

HUMOGEN is the name given to a preparation of peat invented by Professor W. B. Bottomley, of King's College, London, for which high manurial value has been claimed. The substance is prepared by neutralising the peat and then causing it to undergo bacterial decomposition up to a certain point, after which the mass is sterilised and inoculated with a culture of nitrogen-fixing organisms.

Survey of Previous Experiments.

Experiments made at Kew with plants in pots gave extraordinary results, suggesting that humogen had some positive, definite action on plant growth. These experiments have been several times described, so that no further account is necessary. The humogen was used at the rate of 1 part to 7 or 8 parts of soil by volume, a quantity that is quite feasible in pot work, but out of the question for agriculture.[1] Pot experiments with these large amounts were also made at Wisely, and definite increases in growth were obtained which, while in no way sensational, showed that the material is of value to the horticulturist growing plants in pots where economic considerations do not come in. This result is quite intelligible; the addition of so large an amount of organic matter in so fine a condition as humogen could hardly fail to have a good effect

* Reprinted from the *Journal of the Board of Agriculture, London*, April 1917. *See* Editorial Note, pp. 643—645.

[1] No weighings seem to have been made, but taking the ordinary specific gravity values the dressing of humogen in these experiments probably amounted to some 30 to 50 tons per acre.

on the soil in a pot, while the large amount of nitrogen thus introduced adds to the supply available to the plant.

Other experiments however led Professor Bottomley to believe that such large quantities were not necessary and that much smaller amounts would give equally good results. In a paper read before the Royal Society in 1914 he claimed that an extract of this humogen had remarkable stimulating effects on the growth of plants which he considered to be analogous to those obtained by Hopkins and others with the so-called accessory bodies; he therefore supposed that some of these were present, and he gave them the name "auximones." Further, he stated that the auximone could be isolated by precipitation with phospho-tungstic acid, and he obtained in this way a concentrated stimulant which was said to cause remarkable increases in plant growth.

The purpose of our investigations at Rothamsted was to ascertain whether humogen possesses the value for agriculture which the Kew experiments indicated for horticulture. Claims of the most extensive kind had been made; serious journals had printed statements to the effect that the use of humogen might be expected to "double the food production of the country"; some went a little further and spoke of trebling it.

When, however, the basis of these various statements was examined it was found to be somewhat slender, and to consist mainly of testimonials which, as every agricultural investigator is aware, always seem to be forthcoming whenever a new fertilizer is brought before the public. The trials made at the regular agricultural institutions had in the main given negative results, and there was practically no evidence of agricultural value to which exception could not be taken.

The Woburn pot experiments[1] with several crops had given increases when the material was used at the rate of 18 or 36 tons per acre; but as the material is offered at £6 or £7 per ton the cost of such dressings would be prohibitive. Outdoor experiments with applications at the rate of 5 cwt. per acre gave only small results.

[1] *Jour. Roy. Agri. Soc.*, 1915, 76.

The Wisely experiments[1] made out of doors with turnips gave disappointing results which in no sense bore out the claim that humogen contained "50 times as much plant-food as farmyard manure"; 1 ton of humogen gave smaller yields than 20 tons of farmyard manure.

Experiments at the Midland Agricultural College also gave negative results.[2]

More positive results appear to have been obtained at Sparsholt,[3] but the published data are not sufficient to justify detailed discussion. Seven varieties of potatoes were grown; two, King Edward VII and Golden Wonder, gave large increase in crop with humogen, while five gave smaller increases of about 20 to 30 per cent. The basal dressing was 1 cwt. of sulphate of ammonia and 2 cwt. of superphosphate; the amount of humogen added is not stated; the trial was of "humogen basal dressing" against "basal dressing alone," and no comparison was set up between humogen and farmyard manure.

The results were:—

Variety	Unsprayed				Sprayed twice (early and late in July)				Sprayed twice and dressed with "Humogen"			
	tons	cwt.	qr	lb.	tons	cwt.	qr.	lb.	tons	cwt.	qr	lb.
British Queen* ..	4	19	2	11	9	0	3	6	12	12	1	8
King Edward VII ..	3	16	1	10	4	16	1	20	9	1	2	12
Up-to-date ..	7	11	3	14	9	17	2	20	11	8	3	20
Arran's Hope ..	7	9	1	24	8	12	3	2	10	8	3	20
Arran's Chief ..	5	10	3	16	7	7	0	6	9	0	0	0
Golden Wonder ..	4	16	1	20		8	1	26	10	7	1	8
Langworthy ..	3	19	0	17		4	1	24	5	12	2	0

* The seed was all one-year from Scotland, except that of British Queen which was direct from Scotland that season.

As the plots were not duplicated it is impossible to say what degree of significance the results possess.

Other experiments at Sparsholt made with tomatoes also led to increased yields; but in experiments with peas, broad beans, dwarf beans, carrots, beets, parsnips, celery, leeks, currants,

[1] *Jour. Roy. Hort. Soc.*; 1916, 41, 305—326.

[2] *Rept. Midland Agri. and Dairy Coll.*, 1915, pp. 33—35.

[3] *Report on Potato Expts., Sparsholt, Winchester,* 1915.

gooseberries, raspberries, strawberries, apples, pears, and plums, none of these "were affected in the least."

A series of tests with tomatoes and cucumbers made at the Lea Valley Experiment Station[1] gave wholly negative results.

The Rothamsted Experiments.

The Rothamsted experiments were undertaken at the request of the Board of Agriculture in 1915. Professor Bottomley gave full information of sources of material, methods, etc., and arranged at a later date for a visit to the Works at Manchester and at Entwistle. Unfortunately the supply of humogen was not available till the end of May, 1916, and the experimental test was therefore less extensive than had been intended. Of four major tests designed, three were carried out satisfactorily, but the fourth with mangolds at Rothamsted was so delayed that it is not desired to attach much significance to it. The results of all the experiments, however, are in agreement.

In order to eliminate local influences of soil, climate, etc., the experiment was carried out partly at Rothamsted, and partly at the Harper Adams Agricultural College under Principal P. H. Foulkes. The experiment was designed to show the effect of humogen by itself, and in conjunction with farmyard manure, and with farmyard manure and artificials; the last being intended to show whether humogen has any stimulating effect that will help the plant to make better use of the foods already supplied.

Two sorts of humogen were used; one coming from Manchester being prepared by the Cleansing Department from peat excavated on Chat Moss, and the other from Entwistle being prepared by the Entwistle Mountain Peat Estate Company, from the peat overlying deposits of lime stone.

In all cases the results were negative; the humogen had no effect.

The usual dressing was 10 cwt. per acre, this quantity being suggested by Professor Bottomley as being likely to bring out the value of the humogen.

[1] *First Ann. Rept., Expt. and Research Station, Turner's Hill, Cheshunt,* 1915.

Harper Adams Agricultural College.

The results with wheat at the Harper Adams College were :—

Yield per acre.

	Grain	Straw	Total value of grain and straw
			£ s. d.
Humogen 5 cwt.	46¼ bush.	38½ cwt.	26 14 0
No dressing	47¾ „	45½ „	28 6 3

If the humogen had any effect at all it was slightly to depress the crop.

Mangolds. The results with mangolds were :—

Results in combination with dung and artificials.

	With nitrate			Without nitrate		
	tons	cwt.	qr.	tons	cwt.	qr.
*Humogen, 5 cwt. per acre	24	15	3	25	18	0
* „ 10 „ „	27	13	1	28	13	0
† „ 10 „ „	25	7	0	29	5	0
No humogen	28	0	0	28	1	1

*Entwistle. † Manchester.

Results with artificials only. No dung.

	With nitrogen			Without nitrogen		
	tons	cwt.	qr.	tons	cwt.	qr.
*Humogen, 5 cwt. per acre	22	0	3	..	..	..
* „ 10 „ „	23	2	3	20	2	0
† „ 10 „ „	26	11	0	25	18	1
No humogen	22	5	2	23	3	0
Ordinary peat, 5 cwt. per acre	27	5	3	..	..	..
„ „ 10 „ „	28	18	2	..	..	..

Results without dung or artificials.

	tons	cwt.	qr.
*Humogen, 5 cwt. per acre	19	18	1
* „ 10 „ „	19	15	2
† „ 10 „ „	18	10	3
No humogen	17	16	2
Ordinary peat, 5 cwt. per acre	19	5	3

*Entwistle. †Manchester.

In one or two cases where there has been no dung the humogen has somewhat increased the crop, notably when 10 cwt. of Manchester humogen were applied with artificials and nitrate; 10 cwt. of untreated peat, however, gave a still larger increase. The untreated peat was from Westmorland and not from Entwistle but the result does not suggest that bacterisation has effected any very radical change. There seems no reason to assume any very special fertilising action beyond the well-known power possessed by finely divided peat of holding moisture.

Assuming the difference to be real, the 10 cwt. of untreated peat have given an additional 6½ tons of mangolds, while the 10 cwt. of Manchester bacterised peat have given 4¼ tons. On the other hand, the Entwistle bacterised peat has given only 17 cwt. additional crop, a quantity to which no significance can be attached as it lies within the error of experiment. If the result means anything, it is that there is no more difference between the two samples of humogen than between humogen and untreated peat.

Garden crops. A further series of experiments was made on a smaller scale with garden crops. Only in the case of peas and potatoes was any increase obtained as a result of using humogen; the other crops, beans and cauliflowers, were actually depressed. Taking the results as a whole and allowing for the rather large error inseparable from garden crops, one may conclude that they show no increase as the result of applying humogen.

	Peas	Beans	Cauli-flowers	Potatoes	Total
	lb.	lb.	lb.	lb.	lb.
Humogen, 1 ton per acre ..	29½	21½	20	24	95
„ 2 tons „ ..	33	19	26	18	96
„ 1 ton per acre and complete artificials	36	17½	19	14	86½
Ordinary peat	28	28	26½	20	102½
No dressing	27	24	33	15	99

Rothamsted Experimental Station.

Mangolds. Owing to the circumstance that the humogen was not delivered till the end of May, the Rothamsted experiments with mangolds are not so satisfactory as those at the Harper Adams

College. The lateness of sowing caused the plants to be badly affected by drought ; plants on the humogen plots suffered at least as much as the rest. The results of the experiment are :—

	Plot	No. of plants in plot ($\frac{1}{10}$ acre)	Yield per acre in tons
No manure	6	651	4·0
Manchester humogen only	1	518	2·8
Entwistle humogen only	11	603	3·5
Artificials only	7	899	5·4
Manchester humogen and artificials	2	793	4·9
Entwistle humogen and artificials	12	813	6·5
Dung and artificials only	10	926	9·6
Manchester humogen + dung and artificials	5	766	8·5
Entwistle humogen + dung and artificials	15	1,200	13·4

None of these crops is good, the drought having depressed them all considerably.

In one place the humogen appears to have had a good effect, but there is evidence that this is not real. Adjoining Plots 10 and 15 were two others (Plots 17 and 16) receiving complete manure, but no humogen ; though treated exactly alike their yields were 11·2 and 16·5 tons, respectively, *i.e.*, the two plots were under identical treatment, and yet gave exactly the same differences as the two plots, one of which received humogen while the other did not. It is therefore not permissible to attribute the difference in yield to the humogen, but rather to a local difference between Plots 10 and 17 on the one hand, and Plots 15 and 16 on the other. Such local differences come out very strongly in periods of drought and for that reason late experiments rarely give satisfactory results.

Thus the field experiments are uniformly negative. They show no special fertilising effect, and in the only cases where increases were produced they were no better than were obtained from untreated peat.

Mustard in pots. The pot experiments at Rothamsted were carried out under much more favourable conditions than the field experiments described above ; only a small amount of humogen was wanted, and this was obtained in time. The general plan was to apply the humogen at the rate of 10 cwt. per acre, and to give it

also in conjunction with a basal dressing containing potash and phosphates. Half of the controls received nitrate of soda containing nitrogen equal to that in the humogen. The crop sown was mustard and growth was satisfactory throughout.

Again, however, the results were entirely negative and the humogen was without effect; untreated peat had at least as good an action. The figures are as follows:—

DRY MATTER FORMED PER POT. AVERAGE OF 6 POTS.*

Mustard.

	Series	No basal dressing	With basal dressing = 10 gm. Super phosphate and 5 gm. Sulphate of Potash per pot	
		gm.	gm.	
No humogen	1	12·86	15·91	....
Entwistle humogen ..	2	13·015	16·86	5 gm. humogen per pot.
Manchester humogen ..	3	13·00	17·59	5 " " "
Hambledon peat	4	13·34	17·20	5 " " "
Cheshire peat	5	12·47	17·04	5 " " "
Sodium nitrate	6	..	16·36	0·08 gm. per pot: equiv. N. to that in 5 gm. Entwistle peat.
Fish guano	7	..	16·50	0·31 gm. per pot.

Barley in water-culture. The last series of experiments was carried out by Dr. Winifred Brenchley. Professor Bottomley had obtained a 50 per cent. increase in growth of wheat in water-culture by adding some of the extract of bacterised peat. Dr. Brenchley's experiments were made with barley because this plant has certain advantages over wheat for water-cultures; the results are given below.

The plants receiving humogen were rather darker in colour than the others, but the difference in weight is less than 5 per cent., and no significance can be attached to this result.

Peas gave equally negative results.

* The humogen was added at the rate of 10 cwt. per acre, or 0·05 per cent. of the weight of soil in the pots. As an equivalent dressing in series 6 nitrate of soda was added at the rate of 0·16 cwt., *i.e.*, 18 lb. per acre or 0·008 per cent. by weight of the soil in the pots. The weight of soil per pot was 10 kilog., and the basal dressing was 10 gm. superphosphate + 5 gm. sulphate of potash, these being found by experience to be suitable. The fish guano contained nitrogen equivalent to that in the Entwistle peat.

This is in direct disagreement with Professor Bottomley's result, but it is not difficult to account for the discrepancy.

Professor Bottomley's curve looks very convincing, but the figures are less satisfactory. The average weight of his individual plants was about 0·2 gm. *fresh weight*, while that of Dr. Brenchley's plant was 11·4 gm. *dry matter*. It is quite evident that there was something wrong with his cultures, for neither the untreated plants nor those treated with humogen made normal growth; indeed, his control plants actually lost weight. The light and atmospheric conditions at King's College are probably not very good, and are certainly not so good as at Rothamsted, so that, even assuming equal skill and attention, the plants would hardly have done as well as in our laboratories. In view of the very abnormal growth at King's College the writer does not consider that there is any evidence of stimulation of growth.

Water-cultures. Average 10 *plants. Barley.*

Entwistle humogen	Weight of dry matter per plant		
	Shoot	Root	Total
	gm.	gm.	gm.
No humogen (control)	9·35	1·76	11·11
Extract of 0·2 gm. of humogen per plant	9·75	1·74	11·49
„ 0·6 „ „ . .	10·08	1·57	11·65

Summary.

Summing up the results, we find no evidence that humogen possesses any special agricultural value. There is not the least indication that it is "50 times as effective as farmyard manure," to quote an often repeated statement, and there is nothing to show that it is any better than any other organic manure with the same content of nitrogen. It is offered at present at £5 per ton in 2 ton lots; our experiments give no reason for supposing that it is worth anything like so much.

This result is in entire disagreement with the claims made on behalf of humogen, and the question naturally arises: Are those claims wholly without foundation?

In endeavouring to arrive at a solution of this question two circumstances must be taken into consideration: (1) the fact that good results were undoubtedly obtained in pot experiments both at Kew and at Wisely; and (2) the evident variability in the composition of humogen.

(1) The writer is quite prepared to believe that the horticulturists found humogen in the quantities used at Kew and at Wisely a valuable addition to the compost used for potting up plants, but he is not prepared to say that humogen is any better than an equal amount of untreated peat in an equally fine state of division. Such finely divided organic matter will serve several useful purposes in pots, and when it forms 12 per cent. or more of the whole bulk it is present in sufficient amount to exert a useful effect.

It is quite possible that heavy dressings would have good effects on poor soils deficient in organic matter, but they would have to be on a far larger scale than is possible at present prices.

(2) The second point to which attention should be directed is the evident variability of the samples. The analysis published in "The Spirit of the Soil," by G. D. Knox (p. 86), for which Professor Bottomley accepts responsibility, claims :—

Percentage of total nitrogen in humogen .. .. .. 4·310 per cent.

Rothamsted analyses on the other hand show :—

		As sent out	In dry matter
Percentage of total nitrogen in Manchester humogen	..	0·570	1·29
Percentage of total nitrogen in Entwistle humogen	..	0·431	1·32

Here, of course, is an enormous discrepancy. The book seems to indicate that the 4·3 per cent. of nitrogen is contained in humogen as sent out, but even if this is presumed to be an error and the figure is taken to represent the amount in the dry matter, it is still greatly in excess of anything that we find. It must be supposed either that there has been an error in Professor Bottomley's analyses or that the two samples of humogen sent to Rothamsted were considerably poorer than the earlier samples.

Dr. Voelcker has also called attention to the variations in samples sent out, one examined by him containing 0·48 per cent. of soluble nitrogen, while another contained 0·08 per cent. only.

This variability is, of course, highly unfortunate. It is possible that some samples have acted well in the field; it is certain that others have not. There is no definite evidence that "bacterisation" really adds to the value of peat. In the writer's view the wisest plan would be to concentrate on experimental work and stop all propagandist operations until some definite basis of incontrovertible fact has been attained. The latter point is still a long way off; the problem of utilising peat is sufficiently difficult to occupy the whole attention of a laboratory for some years, and nothing but quiet, serious work is likely to solve it.

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EDITORIAL NOTE.

A PROOF of the report of these experiments by Dr. Russell was sent to **Professor Bottomley,** who writes as follows:—

"The results obtained last year by Dr. Russell are not surprising in view of the fact that late last autumn I discovered that the material sent to Dr. Russell, both from Entwistle and Manchester, was not *bacterial* peat but a *chemically treated* peat which contained substances injurious to plant growth. Most unfortunately, there was a serious error in the manufacture of the early lots of humogen sent out from both places. Briefly, what happened was as follows:—At both places work was not commenced until late in March; the machinery available was most inadequate, and the wet peat, as cut from the bog, had to be used at once without any preliminary aeration or drying.

"In the process of manufacture a small amount of sodium carbonate ($\frac{1}{2}$ to 1 per cent.) is mixed with the raw peat, sufficient to neutralise the acidity without producing a soluble humate, before incubating with the ærobic decomposition organisms. In the original manufacture of humogen at Green-ford, the depth of colour of the water extract obtained after incubation with these organisms was used as a guide to the effectiveness of the bacterial decomposition of the peat, and incubation was allowed to continue until a dark coloured extract was obtained.

"As humogen was wanted as quickly as possible last spring for experimental work in order not to miss the season, it appears

that those in charge of the works, well knowing the solvent action of alkalies on peat humus, added an excess of sodium carbonate to the raw peat—in some cases as much as 6 per cent. in order to obtain quickly a soluble humus, and thus, as believed, obviate the necessity for a lengthy period of incubation. This was contrary to my definite instructions as to quantities and time for incubation. The result was that a chemically treated peat, containing an excess of soda, was sent out instead of a properly bacterised peat.

"I had no suspicion that anything was wrong with the early lots sent out until I heard from Messrs. Sutton, of Reading, that their experiments with the material were showing that it contained something which actually checked plant growth, and as this was contrary to what they had anticipated, after seeing the results obtained at Kew Gardens in previous years, they wanted to know the reason. For some time I could obtain no clue, for each time I visited the works everything appeared to be in accordance with my directions, and it was not until September that I was able to locate definitely the cause of the trouble.

"It was impossible, owing to my College duties in London, for me to be present at Entwistle and Manchester when the first lots were being manufactured, hence I had to depend on other people for my instructions being carried out.

"Although the error was beyond my control, I deeply regret that the time and labour involved in the Rothamsted experiments should have been expended on testing a substance which was not humogen.

"That the material sent to Rothamsted was not properly prepared is evident from the negative results obtained by Miss Brenchley with water-cultures. In every other case of water-culture experiments with properly bacterised peat, including those carried out under the supervision of Professor V. H. Blackman at the Imperial College of Science, South Kensington, and which were seen by representatives of your Board, water extracts of bacterised peat have given remarkable results. These results will be published by the Royal Society, and a resumé of them will be given in a later issue of this *Journal.*"

Dr. Russell states that the material was sent to him in May 1916 as true humogen; it was not purchased unknown to the vendors, and Professor Bottomley, the Cleansing Department of the Manchester Corporation, and the Entwistle firm, all knew that it was for the purpose of these trials. Neither then, nor in any subsequent correspondence, nor on the occasion of Dr. Russell's visit to the works at the end of August was there any hint that the material was defective, and the first intimation to this effect was a letter from Professor Bottomley to Dr. Russell on 17th March, after proofs of the present report had been submitted to Professor Bottomley.—[EDITOR, *Journal of the Board of Agriculture.*]

NOT ENOUGH TO EAT*?

BY

AN OLD SETTLEMENT OFFICER.

AT any given moment there are some people in the world who have not enough to eat; what would happen if this were true of everybody, or, in other words, if the quantity of food in the world were not sufficient to keep all its inhabitants alive? Would the nations set to work to eliminate the useless and unfit? Would they engage in a furious struggle to secure more than their share? Or would civilization go to pieces, and leave each man to fight for his own life? Such speculations sound fantastic as well as gruesome, yet it seems to me that there is a possibility of the world having to decide questions of the kind some time in the year 1919, unless it takes timely measures to avert disaster. In carrying out such measures, a large—perhaps the largest—share would fall on India, and since it is not good to hurry India it is worth while to try and form an estimate of the risk, and a general idea of what would have to be done in case the risk should become imminent.

In ordinary times the world does not produce more food-stuffs than it consumes. The cereal year runs from August to July. First come the crops of all the northern countries, together with India's *kharif*; then come the crops of Argentina and Australasia, together with India's *rabi*, and these supplies have to feed the world for the year. If harvests are good, a little is added to the floating stock, which is drawn upon when the yield is bad, but there is no great stored reserve on which reliance can be placed nor would such a reserve fulfil a useful purpose in ordinary times. The first result of

* Reprinted from the *Indiaman*, dated London, May 17th, 1917.

war is to reduce the yield ; labour is withdrawn from the land, the area sown falls, and some of what is sown is badly tilled. The extent of the loss depends primarily on the number of men withdrawn, and in the present case is great beyond all precedent ; it can be minimized by improved organization, but can rarely be wholly made good in this way ; and it is important to realize—what every farmer knows —that the loss from inferior tillage is cumulative as time goes on. The world is now just beginning to get practical experience of these unpleasant facts. In the year ending July 1916, things went well in most important countries, and the grand weather made up the loss, but the present year tells a very different story. Areas sown have been short, weather has been bad, yields have fallen off seriously, and, according to the latest figures issued by the International Bureau of Agriculture, the surplus available from 1915-16 will be used up before the year comes to an end. The world will therefore start next August with low stocks, and the northern crops have made such a bad beginning that it is most improbable that the deficit will be recovered in the autumn ; much therefore will depend on the southern crops to be harvested next spring, and if anything goes wrong with them—for instance, if this year's monsoon is a failure, or if the recent experience in Argentina is repeated—July 1918 will see the world's stocks almost exhausted.

Now suppose that Central Europe comes into the market about that time, a needy buyer—for she will have nothing on hand and will want to replenish stocks at the earliest possible moment—there will be a serious scramble in the summer ; and if the northern crops of 1918 should be poor (which is quite possible, seeing that the shortage of labour will have been at the maximum and that the cumulative effects of prolonged bad tillage will be fully manifested), then the world will be worse supplied with food-stuffs in the spring and summer of 1919 than has ever been the case since the modern grain trade was developed. To sum up, poor crops in 1917-18 and poor crops in northern countries in 1918-19 may bring us to the verge of a world-famine ; no one can say how great the risk is, but by next February it will be possible to gauge the situation fairly well, and if the risk is real the Government of India must be prepared to

act by May. It has effecti machinery at its disposal, provided that the start is not delayed , ut the start will take time, and the plans should be ready beforehan The reason why May is indicated as the month for action is to be found in the interdependence of the Indian seasons.

The cultivator usually plans his cropping for the year before the rains break, assigning some of his land to *kharif*, some to *rabi*, and perhaps some to both seasons, and if the Administration is to intervene effectively it should do so before those plans are translated into action. A field sown with cotton, for instance, is pledged for a whole year, unless the extravagant measure is adopted of ploughing it up ; if it is wanted to yield food in one season, or in the other, or in both, the fact should be made clear before the cotton is sown, that is, well before the end of May in most of the country, and substantially earlier in the districts served by the canals.

The scheme of operations is fairly obvious. Something could doubtless be effected by extending cultivation through liberal provision of the capital required; but, in my opinion, too much reliance should not be placed on large schemes of breaking up the jungles. The men and cattle required for this operation would not be on the spot ; to move them to it would involve the denudation of land already under tillage ; and while there are obvious attractions in the idea of a few ship-loads of American motor-ploughs and tractors, accompanied by men knowing how to use them, there are also difficulties with which every student of the subject is familiar. Such schemes should not be overlooked, but in my judgment reliance should be placed mainly on the land already under settled cultivation and equipped with labour, cattle, and implements, which, if not efficient in the Western sense of the word, are yet organized as a tolerably effective going concern.

Nor can a large increase in the yield of this land be suddenly brought about. The present standard in some parts of the country is indeed deplorably low, and a large increase is a matter of the utmost importance ; but it can only come gradually and as the result of a progressive improvement in the local agriculture. In order to make the best use of the existing resources, India must

give up most of her industrial crops for both seasons of 1918-19, concentrate her energies entirely on food grains, double and treble crop every acre that can be watered, and in a word increase her output by as many million tons as possible ; she is one of the few countries which can talk lightly about millions of tons, and with twenty odd million acres under cotton and perhaps sixteen millions under oilseeds, to say nothing of such side lines as jute, she is in a position to add to her production an amount which might make all the difference to the world. The kind of grain sown is a minor matter ; wheat, of course, is best, but barley and gram, rice, maize, and the millets will all keep people alive, and if the emergency should unhappily be realized, the question for the world will be one of existence and nothing more. In that case the first duty of the Administration will be to mobilise the people on the work they can do best, not, of course, on philanthropic lines, but on terms which ought to leave India very much richer than she is to-day.

It may be objected that in a crisis such as I have indicated the supply of shipping would run short, and that the extra food could not be transported. This is perfectly possible, and I have no doubt that in a world-famine it would be necessary, instead of bringing food to the people, to carry some of the people to the food ; the ships would carry food one way, and men and women the other. India would not be a wholly desirable camping-ground in summer, but it would be preferable on the whole to starvation in Europe, and the question may be one of starvation if things go seriously wrong. The whole idea may, as I began by saying, sound fantastic, but I do not recollect that even two years ago we contemplated dealing out bread by the ounce, and sugar by the lump, as we are doing to-day, and we may have many equally unforeseen experiences before we finally succeed in clearing up the mess which German ambitions have made of our modern world.

THE FIRST MODEL FARM.*

THE staff and students of the Agricultural College near Cawnpore may be interested to learn that the first attempt—conducted under British auspices—to introduce improved methods in Indian agriculture was made in the district where the institution they belong to stands. So far back as 1814 a model farm, essential adjunct of the modern school of agriculture whose object is to give practical demonstration of the benefits obtainable by using superior kinds of seed, working in accordance with the recent discoveries of science and with a better type of implements, was started on in the neighbourhood of Bithur. That locality had been chosen because of a piece of rich land in the immediate vicinity of a town which became notorious some years afterwards as the abode of the infamous Nana Sahib. The founder of the farm dignified it with the title of "Fatehgarh Agricultural Society," and Sir Edward Colebrooke—known to a past race of Urdu and Sanskrit scholars for his linguistic abilities and the grammars he compiled on the languages of the East—consented to be President of that novel bantling of British enterprise in India. The creation of the farm was the work of Mr. Ravenscroft, Collector of Cawnpore, when the district was much larger than is now the case; including pergunnahs of the present Farrukhabad, Etawa, and Fatehpur jurisdictions. Officials in those far away times evidently had leisure for matters outside the routine labours of the Cutcherry, since Mr. Ravenscroft conducted farming experiments on his own account to commence with and—finding the venture a profitable one—besought Government to undertake a like scheme but, of course, on a larger scale. His demand was not of an extravagant nature merely involving 500 acres of land being treated in accordance with the best European ideas on farming, and his ambitions

* Reprinted from the *Pioneer*, dated 1st June, 1917.

did not reach as far as the formation of a college where Indians could be taught the agricultural art, although he expressed a wish that what he called a " National Farm " should be gradually developed. With the rashness that seems to have been one of his chief characteristics, Mr. Ravenscroft pledged himself to cover all initial expenses connected with the proposed farm ; confident from the results of his personal experiences that the out-turn would more than recoup the outlay. Apparently a district officer was then permitted to correspond direct with the fountain head, for we have read a letter addressed to the Marquis of Hastings, Governor-General at the time, penned by Mr. Ravenscroft, and well worth perusal, it only to note the vast change that has taken place in the tone and language of official correspondence a century ago and now. It must have been a great advantage for the man in charge of a district to lay his views before the head of Government instead of running the risk of their finding an early grave in some secretariat pigeonhole or (still worse fate) forming the basis of an inquiry extended over several years, till the originator of a scheme on behalf of a particular locality had lost all interest in the matter and grown heartily sick at the needless obstacles raised by persons little acquainted with the actual conditions of his pet plan. There are still, one fears, a good many Sisyphuses in an Indian Department—men who, like Mr. Ravenscroft, have had the daring to suggest sundry departures from the recognized order of things and who fail to enlist the sympathy or interest of the higher authority whose sanction is required ere theory, however sound, can be put into practice.

The most rabid opponent of what is termed a "classical education " would be forced to admire the neatly turned periods, the almost Ciceronian prose, of the official document just referred to. It contains—in addition to a remarkably clear statement regarding agricultural prospects and possibilities in these provinces—an apt quotation from the works of Pliny and a still more effective allusion to the definition of agriculture given by Sully—the famous Minister of Henry of Navarre. Latin quotations are banished from official correspondence as much as from speeches in the House, and that language and its companion Greek have become dead languages in

reality where public life is concerned. A Lieutenant-Governor when addressing an audience of University students may occasionally pay his hearers the graceful compliment of illustrating his remarks by a line from Horace, an appropriate axiom from Plato or one of the Greek dramatists, otherwise, an uneasy suspicion that you will be deemed a dull pedant or—more probable—that your borrowed wisdom may not be fully comprehended by the individuals to whom it was addressed, compels the modern orator to confine himself to his native tongue.

Unfortunately for this model farm, pioneer of the excellent institutions of the same kind now flourishing in every province of India, the founder of the movement came to sudden and irretrievable grief. Mr. Ravenscroft has been described by one of his contemporaries as the keenest of sportsmen and an adept in most forms of Indian athletics and manly exercises, such as sword-play, wrestling, and the like. Cockfighting had not been denounced as a barbarous amusement, and he is said to have lost very large sums betting on the mains held at Lucknow—as depicted in the fine picture by Zoffany—and doubtless also in Cawnpore then—the fact is mute testimony to British enterprise—looked on a frontier station. In an evil moment Mr. Ravenscroft, harassed to meet heavy losses in cotton speculations, yielded to temptation and " conveyed " a big sum of Government money from the treasury to his own pocket. Mr. Ravenscroft's sporting proclivities must have brought him in social contact with numbers of the Indian aristocracy, so he had little difficulty in finding shelter beyond the reach of the Company's legal myrmidons. The place he selected as a safe refuge was Bhinga in the Bahraich District, seat of a branch of the great Bisen clan of Thakurs, and there he met with a warm welcome from the Raja. According to Oudh ethics in those days, to possess yourself of Government rupees by unlawful methods was a very venial offence. Adhering to his old taste for agricultural development of sort, the fugitive soon persuaded his host to start indigo cultivation and probably would have made the undertaking a financial success. The son of the Raja, however, did not approve of the advent of a European stranger, more especially when the latter was clearly in

the good books of the owner of the estate, so employed a gang of armed ruffians—most likely Bhadaks, a criminal tribe whose depredations in the shape of dacoity and highway robbery were notorious for many years later in the districts of Gonda, Bahraich, Basti, and Gorakhpur. An Indian friend chanced to be staying with Mr. Ravenscroft when the house of that gentleman was attacked by the gang, and from history details of the affray were slowly collected by British officials. It was not before seven of his assailants had been killed and nearly a score of them wounded that the ill-starred European fell a victim to overpowering numbers. His tomb can still be seen not far from the present abode of the Bhinga Rajas.—[A. N. G.]

FIFTY YEARS OF INDIAN COTTON CROPS—1863-64 TO 1912-13.*

WITH NOTES ON THE THREE LAST ONES.

Area.

ONLY in the last five-and-twenty years have complete returns been officially published of the area under cotton, only about twenty of which apply to the half-century. Between the five-year periods ending 1897-98 and 1912-13, the quinquennial mean rose from 15¾ to 21 million acres, equal to 36 per cent. The yield per acre on the official estimates improved from 64 to 76 lb., but on the "approximate crops" from 83 to 93 lb.

(The record crop of 1913-14, the first following the half-century, was gathered on an area of 25 million acres, equal to 85 lb. on the official estimate of 5,065,000 bales, but of 107 lb. on the approximate crop of 6,684,000 bales of 400 lb.)

Out-turn.

In the twenty years ending 1882-83, the approximate crops averaged from 2 to 2¼ million bales, in the next five 2¾ million, followed by two of 3¼ million; in the subsequent one by nearly 3¾ million, and 4½ million in the next five, every year exceeding 4 and one 5⅛ million, while in the last five the average was just under 5 million.

(The crop of 1913-14, as just stated, approached 6¾ million, the following one 5¼ million, and the last 5½ million.)

In the last twenty years (of the fifty) the official estimates of yield—not previously issued—proved, on an average, too conservative by about 30 per cent. In the first five years ending 1897-98, they were too low by 850,000 bales (35 per cent.), in the next five by no less than 1,069,000 bales (41 per cent.), in the following period by 865,000 bales (23½ per cent.), and in the last by 913,000 bales (22½ per cent.).

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* Reprinted from the *Journal of the Royal Society of Arts*, April 13, 1917.

Distribution of Indian Cotton Crops in thousands of bales of 400 lb.

5 years mean, ending June 30th	Exports to				Home Consumption			Exports and home consumption	Less imports	Approximate crops	Official estimate of yield	Excess	
	U. K.	Cont.	Far East	Total	Mills	Local	Total					Bales	Per cent.
1867–68	1,285	100	74	1,459	65	600	665	2,124	10	2,114		Not available.	
1872–73	1,243	230	94	1,567	114	604	718	2,285	12	2,273		Do.	
1877–78	721	500	60	1,281	193	619	812	2,093	15	2,078		Do.	
1882–83	454	753	90	1,297	355	638	993	2,290	16	2,274		Do.	
1887–88	574	829	55	1,458	640	677	1,317	2,775	17	2,758		Do.	
1892–93	235	1,158	98	1,491	1,083	716	1,799	3,290	25	3,265		Do.	
1897–98	94	831	299	1,224	1,351	729	2,080	3,304	22	3,282	2,432	850	35·0
1902–03	66	742	578	1,386	1,592	738	2,330	3,716	33	3,683	2,614	1,069	40·9
1907–08	91	1,242	597	1,930	1,917	746	2,663	4,593	33	4,560	3,695	865	23·4
1912–13	98	1,077	977	2,152	2,017	850	2,867	5,019	76	4,943	4,032	913	22·6
												Mean	30·5
Years													
1913–14	166	1,899	1,472	3,537	2,143	1,000†	3,143	6,700	16	6,684	5,065	1,619	31·9
1914–15	169	623	1,408	2,200	2,103	1,000†	3,103	5,303	24	5,279	5,209	70	1·3
1915–16	137	431	1,898	2,466	2,100*	1,000†	3,100	5,566	7	5,559	3,819	1,740	45·6
1916–17													
												Mean	26·3

* Estimate. † Official estimate.

Home consumption.

Accurate returns of the quantities exported, as well as of the consumption by the mills, are available. Our notes are based on tables for the years ending June 30th, the end of the Bombay season, the export statistics being compiled from the returns of the Bombay Chamber of Commerce and of the mills from those of the Bombay Mill Owners' Association. The only element of uncertainty is the local, other than mill, consumption. The official estimates regarding this have fluctuated in a remarkable manner, 400,000, 250,000, 750,000, and a year or two ago, after consultation with the Bombay Cotton Trade's Association, a million bales. The data on which this estimate was arrived at have not been stated, but even if they are approximately correct the consumption of the country, for purposes other than spinning by the mills, has risen to 1¼ lb. per head. Half a century ago it was placed at 600,000 bales by Mr. Rivett-Carnac, the Cotton Commissioner of the Central Provinces and Berar. This was then equal to about 1 lb. per head. At that time the mill consumption was barely 65,000 bales, equal to about 3 per cent. of the two million bales produced, while the local consumption was equivalent to over 28 per cent. To-day the respective proportions are nearly 40 and 18 per cent. The mill consumption in the first half of the fifty years rose from 3 to 23 per cent., in the next five to 33 per cent., in the following fifteen fluctuated between 41 and 43 per cent., and in the last five averaged 41 per cent.

(Of the large crop of 1913-14 the ratio fell to 32 per cent., but in the last two averaged about 39 per cent.—2,100,000 bales.)

Exports.

During the first half of the fifty years the proportion of the crops exported—1¼ to 1½ million bales—of the total available supply fell from 69 to 53 per cent., in the next five (one million) to 46 per cent., in the following two quinquennial periods (1½ million) to 37½ per cent., then rose (2 million) to 42½ per cent., and in the last five years (2 million) to 43½ per cent.

[In 1913-14 over 53 per cent. (3½ million) were shipped to foreign countries, 41½ per cent. in the next year (2¼ million), and 44½ per cent. (2½ million) in the last.]

The opening of the Suez Canal in the middle ot November 1869, marked a great change in the direction in which Indian cotton was exported. In the five yeais ending 1867-68 nearly 69 per cent. was shipped—61½ per cent. to Great Britain, 4½ per cent. to the Continent of Europe, and 3½ per cent. to China and the Far East. Twenty years later the respective shares were 21, 30, and 2 per cent., the direct despatches to the Continent *viâ* the Canal rapidly reducing England's carlier re-export trade. In the last five years of the half-century the proportions had changed to 2 per cent. to the United Kingdom, 22 per cent. to the Continent, and 20 per cent. to Japan principally and the Far East.

(Of the 1913-14 record crop, Great Britain took but 2¾ per cent., the Continent 28½ per cent., and Japan, etc., 22 per cent., while last season, owing to the war, the respective figures were 2½, 7¾, and 34 per cent.—total, 44½ per cent.)

Imports.

India imports little cotton from other countries. In the first forty-eight years of the half-century they averaged 25,000 to 35,000 bales, the bulk from Persia. But in 1911-12 over 135,000 bales (of 400 lb.) were imported from America and Egypt, and 175,000 bales in the following year, dropping again in the last three to less than the former normal.

COTTON INDUSTRY IN CHINA.*

THE FOREIGN IMPORT.

CHINA'S importations of cotton from foreign countries are increasing, and these importations will continue to increase as the mills increase, because, as has already been pointed out, the finer yarns cannot be spun from Chinese cotton and unless the mills are to confine their output to weight and not length or fineness, they must continue to import American and other cotton for their finer work. From September 1, 1915, to August 31, 1916, Shanghai alone imported from foreign countries 340,809 piculs† of raw cotton as compared with 247,122 piculs the previous year. The usual local yarn is 12's to 16's and if the mills wish to spin 20's or finer they must depend on imported cotton, as the local staple is not suitable for anything finer than 16's........Shensi cotton, which is an American strain introduced into China, is about the only Chinese cotton that can produce a finer yarn than 16's, and at the same time obtain a satisfactory production ; and what China needs is more cotton of the Shensi type, or finer. The opening quotations for the new season cotton this year were Tls. 26 for Shensi, Tls. 24·50 for Tungchow, and Tls. 23 for Shanghai. Should China raise finer cotton there would be less cotton imported which is only another reason why China should start a chain of experimental bureaux.

When you pay $1·50 a pound for a packet of medicated cotton which your chemist imports from America, the probabilities are that that same cotton originated in China and when it was exported from this country it was valued at about 20 cents. China's export cotton trade is a considerable one and about half of the exported cotton goes to Japan. There is a special grade of cotton peculiar to Shantung in much demand in America, where it is prepared as

* Extracts from an article in the *North China Herald*.

† A *picul* = 133⅓ lb.

medicated cotton for which it is especially adapted, as it is so white that it requires no bleaching. It is a short fibre and harsh to the touch, so it makes an admirable imitation wool either when used alone or mixed with wool in the manufacture of cheap hosiery and underwear. America has paid up to 7½*d.* for Chinese cotton quite recently.

* * * * * * *

The local mills are already manufacturing certain goods that were formerly imported into China in large quantities from Germany, as are the Japanese mills at Osaka.

Manchester of the Far East.

Considering the remarkable growth of the local spinning and weaving industry during very recent years, it is only reasonable to expect that the future will see Shanghai developed into the Manchester of the Far East, provided, however, that the manufacturers are given reasonable protection by the Chinese Customs so that they may be allowed to compete on a fair level with the mills of Japan. Given this protection, the possibilities for expansion seem almost unlimited when it is considered that all of China's millions are clad in cotton clothing. That there is ample room for vast increase in the number of power-driven spindles and looms may be judged from the following estimated figures for the three Far Eastern countries interested in cotton mills :—

	Population	Spindles	Looms
China	400,000,000	1,050,000	5,000
India	278,000,000	6,400,000	28,000
Japan	52,000,000	2,414,544	24,000

That Japan, a non-cotton growing country, should have succeeded in developing the mill industry to such an extent, while China, a cotton-growing country, lags behind, speaks volumes for the energy of the Japanese and for the far-sighted policy of the Japanese Government, for Japan could not have so developed the industry in 25 years had she not had a protective tariff which places raw cotton on the free list and heavily taxes manufactured cotton when imported.

Checks on Adulteration.

Modern cotton manufacturing was introduced into China in 1890 and was extended after the Chino-Japanese war, considerable foreign capital having been put into local mills in 1896 and 1897. Up to 1902, however, there were no returns on the investments owing to the rapid increase of spindles and the inefficient supply of native cotton which was not equal to the demand, and the fact that the price of raw cotton, because of the shortage, increased out of proportion to the price of yarn. The demand for the raw material, however, was met by increased acreage, and the mills have been more prosperous during recent years.

It has long been the local practice to adulterate cotton by adding water to it for the purpose of increasing the weight. After fourteen years of endeavour, in 1911, the Watered Cotton Association was recognized by Peking with the result that the Shanghai Cotton Testing House was organized with an officer attached to it on detail from the Customs. The testing of cotton against water and other adulteration has led to very beneficial results during the past few years. The associated mills, under the rules of the House, are not allowed to accept cotton carrying over 15 per cent. water, and an effort is being made to keep the moisture down to 12 per cent., the natural moisture carried by American cotton is 8 per cent., and in China commonly it is 10 per cent. although Shensi cotton is naturally so low as 9 per cent.

An Unequal Tariff.

Under the present tariff China follows the absurd policy of taxing home industry more heavily than foreign, and mill-owners are anxious to have the tariff revised so that the Government would foster home industry on the lines adopted in America, Japan, and other countries. China grows cotton, yet she exports half to Japan whence it is returned in the form of yarn and cloth which could be made here. When the mills in Shanghai use Shensi, Shantung, Hupeh, or other cotton not grown in this province, at the port of entry the Customs levy a duty of Hk. Tls. 0·35 per picul and again Hk. Tls. 0·175 per picul import duty at Shanghai, in all

Hk. Tls. 0·525; yet a mill in Japan, using the same cotton, only pays an export duty of Hk. Tls. 0·35, and is better off by 17½ candareens per picul so far as taxation is concerned, although it is admitted that the manufactured goods pay duty when imported. The mills naturally avoid, so far as possible, using cotton from other than their own districts with the result that a large part of the crop raised in provinces not adjacent to Shanghai is exported to Japan and returned to China in manufactured form. The demand for foreign cotton which is indispensable for certain purposes is increasing annually and mills in China are at a considerable disadvantage as compared with Japan, for local mills have to pay duty on the imported cotton while Japan gets it free of duty.

The following figures show approximately the tax paid to the Government on a bale of yarn from a foreign country in China and in Japan; while Japan has no duty on raw cotton, China levies Hk. Tls. 0·60 per picul. Allowing that piculs 3·45 of foreign cotton make a 3-picul bale of yarn, such a bale spun in China pays—

Import duty at 0·60 Hk. Tls. a picul	Hk. Tls.	2·07
Excise on yarn at 70 candareens per picul.	,,	2·10
		4·17

A bale of similar yarn made in Japan from the same cotton when imported into China pays—

Import duty at 95 candareens per picul.... Hk. Tls. 2·85

The spinners here pay Hk. Tls. 1·32 more than their Japanese opponents.

The remedy is to put cotton on the free list, that is to remove the import duty on foreign raw cotton, and abolish the excise and likin taxes so that yarn and cotton may be transported to all parts of China, free of taxation.

RESEARCH AND THE COTTON INDUSTRY.

We have been asked by the Secretary, Committee on Cotton Research, to publish the following:—

At the end of July of last year, at the instance of the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research, a meeting of representatives of some of the larger firms engaged in the various branches of the cotton trade and others interested in textile research was called by the Lord Mayor of Manchester to consider the possibility of establishing a scheme for the scientific investigation of the various problems presented by the cotton-using industries, and it was agreed that there is great need for research bearing on the cultivation and manufacture of cotton, and in the dyeing, printing, bleaching, and other finishing processes. It was also thought that efforts should be made to increase and to improve the system of textile education. At an adjourned meeting it was decided that some practical steps should be taken to organize a complete scheme for these two purposes. A Provisional Committee was appointed and this, in due course, was constituted a Committee of the Advisory Council of the recently formed Government Department of Scientific and Industrial Research.

This Committee is largely representative of the various interests concerned. Its function is to formulate a preliminary scheme of a comprehensive character and to report to the Advisory Council, and then to lay before the trade, for its consideration, definite proposals for the establishment of a Research Association, eligible for recognition by the Government Department and consequently for monetary grants from the National Exchequer.

The Provisional Committee consists at present of the following members:—Mr. J. W. McConnel (Fine Cotton Spinners' Association, Ltd.), Chairman; Mr. H. R. Armitage (Bradford Dyers' Association,

Ltd.); Dr. W. Lawrence Balls (late of the Khedivial Agricultural Society of Egypt and the Egyptian Ministry of Agriculture); Messrs. T. D. Barlow (Messrs. Barlow & Jones, Ltd.), F. W. Barwick (Manchester Chamber of Commerce Testing House), Stanley Bourne (Cotton Doubler, representing the Nottingham Chamber of Commerce), Lindsay Cropper (Messrs. J. & P. Coats, Ltd.), Henry P. Greg (Messrs. R. Greg & Co.), J. C. M. Garnett (Manchester School of Technology and the University of Manchester), A. E. Hawley (Dyer, representing the Leicester Chamber of Commerce), Forrest Hewit (Calico Printers' Association, Ltd.), E. L. Hoyle (Messrs. Joshua Hoyle & Sons, Ltd.), Alfred J. King (Bleachers' Association Ltd.), Kenneth Lee (Messrs. Tootal Broadhurst Lee Co., Ltd.) J. H. Lester (late of the Manchester Chamber of Commerce Testing House), James Prestwich (Federation of Master Cotton Spinners' Association), Fred. J. Smith (British Cotton and Wool Dyers' Association, Ltd.), and Charles H. Turner (Cotton Spinners' and Manufacturers' Association). Mr. A. Abbott, H. M. Inspector of Technical Schools, has been appointed by the Advisory Council, with the concurrence of the Board of Education, to act as Secretary *pro tem.*

The Provisional Committee are holding fortnightly meetings. They have to consider the place for research in each branch of the cotton industry, whether in the cultivation of cotton, in spinning, doubling, manufacturing, knitting, lace-making, bleaching, dyeing, printing, finishing, or in the technology of cellulose. They have also to ascertain what facilities now exist for the education of boys entering any of these branches, and what opportunities are likely to be offered by the trade for the employment of highly trained men. To complete their labours they will have to formulate a scheme both for an Institute to undertake research work in collaboration so far as practicable with existing bodies and for an Association of firms and individuals willing to make donations and subscribe regularly for a period of years to promote research and improve technical training.

The terms and limitations under which the Association can obtain its share of the million pounds granted by the Treasury to

promote scientific and industrial research will be ascertained by the Provisional Committee.

Any suggestions relating to the researches to be undertaken or to any other matters coming within the scope of the proposed Association will be welcomed by the Committee, and should be sent to the Secretary, Provisional Committee on Cotton Research, 108, Deansgate, Manchester.

Notes.

BRACKISH WATER WELLS IN THE AGRA DIVISION.

THE tract in the Agra Division where brackish water occurs in the wells is the south-western portion. In the northern and eastern portions of the Division brackish wells hardly ever occur. In the matter of salt the Bharatpore State is even worse off than the Muttra and Agra districts.

The first point for consideration is what is the origin of the salt in the sub-soil? Geologists say that in the Indo-Gangetic plain there is no trace of marine formations and that the strata down to very great depths far below the present sea-level are of fresh water origin. We cannot, therefore, suppose that the salt in the soil is due to the alluvium having been laid down in sea-water.

For many years it was an unsolved geological problem why deposits of rock salt were generally associated with desert sand and not with sea sand. The two classes of sand are easily distinguishable because sea sand remains fairly coarse and sharp while desert sand which is blown about gets ground down much finer and has its rough edges rounded off.

A few years ago it was proved by experiments made by some officers of the Geological Survey that all the salt in the Sambhar Lake salt area can easily be accounted for by aerial transport of salt dust from the Rann of Cutch where the salt crystallizes out during the summer. This possibility of aerial transport of salt, coupled with the concentration of the salt in particular localities by the rapid evaporation of water standing in depressions in an arid or

semi-arid tract, gives a rational explanation of the frequent association of rock salt with desert sand.

It seems probable that the theory of aerial carriage of salt which is a sufficient explanation of the salt in the Sambhar Lake area is a sufficient explanation also of the salt in the sub-soil of the Agra Division.

Thirty or forty years ago, a boring was made in the garden of the Central Jail at Agra to a depth of over 400 feet. That boring showed that the upper 150 feet consisted largely of wind-blown sand and not of true alluvial deposits (*Records, Geological Survey,* XVIII, 121).

It is an interesting fact that, in several cases in the Muttra District, sweet water has been found at a depth of 200 feet although the surface water was salt.

The deductions which we are tempted to draw from these facts are: (1) That the physiographical conditions existing during the deposition of the upper 150 feet of the alluvium at Agra have been distinctly different from those previously existing; (2) that during the time when the last 150 feet of alluvium was laid down the conditions were such as to favour the aerial transport of salt from some such source as the Sambhar Lake or the Rann of Cutch; and (3) that the salt in the sub-soil of the Agra Division is of aerial origin.

How then are we to account for the fact that the salt tract does not extend much further than it does, and that the salinity of the soil appears to vary so much from place to place?

The answers to these questions appear to be (1) that the further we get away from the desert area into the area where there is a good rainfall and large rivers, the less would there be of aerial deposition of the soil and the more of true alluvial deposits; (2) that where rainfall is abundant and evaporation comparatively unimportant and especially where the movement of water through the sub-soil is considerable, any salt, which originally may have been deposited along with the soil, will be dissolved and carried away into the rivers and thence into the sea instead of being concentrated in particular localities.—[E. A. MOLONY.]

PROGRESS OF CO-OPERATION IN INDIA.

THE Statements showing the Progress of the Co-operative Movement in India during the year 1915-16, issued by the Government of India, give a detailed record of the main statistics relating to co-operative societies in the several provinces in India during the year under report. The figures given relate to societies of a co-operative nature in all the British Provinces except Delhi, the N.-W. F. Province, and Baluchistan where the movement has yet made no progress. Figures for the Native States of Mysore and Baroda are also included. The statements show that at the end of the year under review there were 19,675 societies of all kinds as against 17,327 in the previous year. The membership increased from 824,469 to 918,436 and the working capital from Rs. 8,96,61,722 to Rs. 10,32,67,149. Capital is increasing slightly faster than membership, being now over Rs. 112 per member as against Rs. 108 for last year. The number of small agricultural societies has so increased that the average membership is now 46·6 as compared with 47·5 in the previous year, while the capital per society has increased from Rs. 5,174 to Rs. 5,250. The Punjab heads the list as it has the largest number of societies (3,393), the largest number of members (148,043), and the largest working capital (Rs. 2,05,63,428). We give below the figures for the other major provinces :—

Province	Societies	Membership	Working capital
			Rs.
United Provinces	3,188	121,843	1,20,34,851
Madras	1,800	137,498	1,68,88,833
Bengal	2,244	121,833	1,24,48,673
Bombay	992	106,817	97,66,759
Burma	2,251	46,311	1,03,39,604
Central Provinces	2,685	65,723	87,09,187
Bihar and Orissa	1,297	61,426	43,27,502

Of the 321 cattle insurance societies in India, 305 are in Burma. The only other provinces in which societies of this kind have been started are Coorg, the United Provinces, and Bengal, which have ten, five, and one respectively.

A study of the statements leaves the impression that the development of the Co-operative movement in India has tended to

be too exclusively agricultural. While the number of agricultural primary societies increased by 1,775 during the year under review (from 15,954 to 17,729 excluding insurance and reinsurance societies), the increase in the number of non-agricultural societies was 105 (from 914 to 1,019). The aim with which the movement was started in India was no doubt to finance the agricultural classes, but a stage has now been reached at which it appears desirable that more attention should be paid to the formation of non-agricultural societies in order to ensure that the small artisans and the labouring classes generally shall receive the same benefits from co-operation as have agriculturists. It is obvious that an increase in the number of non-agricultural societies would strengthen the position of the central banks which would have wider field for their operations and would be less affected by a crisis in any particular occupation or trade.—[WYNNE SAYER.]

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HOME-GROWN SUGAR.

C. C. writes in *Nature*, dated May 31st, 1917, as follows :—

THE announcement in the *Times* of April 19th, that the Treasury has sanctioned a grant of £125,000 by way of loan from the Development Fund towards the purchase of an estate for the purposes of sugar-beet growing and sugar manufacture marks an advance of the highest importance towards the establishment in this country of this valuable industry.

For many years an active propaganda directed towards this end has been carried on, and much valuable preliminary investigation has been completed. Numerous experiments in different parts of the country have shown conclusively that over wide areas sugar-beet crops fully equal in yield and quality to those of the Continent can be grown, and the ground has been effectively cleared for putting the possibilities of the industry to practical test.

For several reasons, however, previous efforts to establish the industry have met with but scant success. On one hand the uncertainty as to national policy in relation to the once vexed question of sugar bounties has been a potent inhibiting factor, whilst on the

other the necessary establishment of sugar-beet growing areas round the factory to give an assured supply of beet has also presented the greatest difficulties.

Repeated efforts to obtain State assistance have encountered the obstacle that such assistance could be given only to enterprises from which the element of private profit was entirely eliminated. At long last, however, the efforts appear to be within sight of fruition, and with the more clearly realized need for the establishment of the industry and the closer consideration given to the solution of the difficulties involved, a scheme has been devised which Lord Selborne's committee in its interim report felt able to endorse as well thought out and sound.

This enterprise for which Treasury support has been obtained is to be carried out by the British Sugar-Beet Growers' Society, Ltd., an organization not trading for profit and created specifically for the purposes of the scheme, with Captain Beville Stanier, M.P., as chairman, and an influential and representative committee, with expert advisory assistance. Through the vice-chairman, Mr. E. Jardine, M.P., an estate of 5,600 acres has been acquired at Kelham, near Newark, where it is proposed to grow a large area of sugar-beet and to erect a factory for its manufacture into sugar. The estate is very favourably situated for both rail and canal transport, and would appear to be well adapted in every way for the purpose.

The enterprise, when fully developed, is estimated to cost £500,000, but, for obvious reasons, only a very limited development is possible at present. With the large acreage at its disposal, some of the difficulties which have beset earlier enterprises are obviously greatly reduced. The scheme also presents other features which inspire confidence in its ultimate success, and the progress of this important national experiment will be watched on all sides with the greatest interest.

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BERSEEM ON SUKKUR FARM, SIND.

In the Annual Report of the Sukkur Farm for the year 1915-16 Mr. Main reports that "berseem (*Trifolium alexandrinum*) fodder commands an excellent market in Sukkur especially in the hot weather

when other sources of fodder become exhausted. Thus in the year under report in December-January the standing crop commanded Rs. 15 per cutting per acre. Later on owing to the increasing thickness of growth a price of Rs. 40 per cutting per acre was realized while in April and May a few plots were actually sold for Rs. 52 per cutting per acre." This is very interesting considering that before the Sukkur farm was started leading district zamindars told the writer it was no good to grow berseem in Sind as no one would buy 'grass.' In the first few seasons the berseem had to be practically given away, but now local prejudice seems to have disappeared. These remarkable prices have been realized on land which was of little or no value, and it still contains some 'kalar,' or 'reh' or more probably its physical texture is defective in places owing to soil colloids formed during reclamation.—[G. S. HENDERSON.]

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REVENUE OFFICERS AND AGRICULTURAL STATIONS.

THE Government of Madras, considering it desirable that District Officers of the Revenue Department should keep in touch with the Agricultural Department and acquaint themselves with the possibilities of agricultural development in their districts, have ordered that Collectors of districts in which no farms have hitherto been established would be permitted to visit "on duty" agricultural stations within a reasonable distance from their headquarters. Collectors have also been authorized to permit selected Divisional Officers and Tahsildars to visit departmental farms in case such visits are likely to be turned to good advantage. The officers have been asked to arrange their visits at such times when the Deputy or the Assistant Director of the Circle can conveniently show them round so that they may have an opportunity for a free discussion over matters agricultural. This is certainly a step in the right direction and we commend it to the notice of other Local Governments. The Revenue Department being in close touch with the agriculturists is in a position to help forward considerably the cause of agricultural

improvement if Tahsildars and Deputy Collectors take more interest in the work of the Agricultural Department.—[EDITOR.]

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A CANVAS-ATTACKING FUNGUS.

MR. J. RAMSBOTTOM, of the Department of Botany, British Museum, writes in *Nature*:—

So many inquiries have been made from strangely diverse sources, especially since the outbreak of war, concerning black spots which appear on bell-tents, sails, aeroplane and airship fabrics, etc., that it seemed desirable to write the present note principally to direct attention to a paper by F. Guéguen in *Comptes rendus*, vol. CLIX (1914), p. 781, " Sur l'alteration dite ' piqûre ' des toiles de tente et des toiles à voile." The spots are caused by fungi which damage the fabric, so that after some months it is easily torn. The fungus hyphæ grow on the surface of the fabric, between the fibres and within the lumen of the fibres. Guéguen found that the fungi principally concerned were the Pyrenomycetes, *Pleospora infectoria* and *P. herbarum*, especially the former. These Ascomycetes are also found in their conidial states, *Alternaria tenuis* and *Macrosporium commune*, and other Mucedineæ, Rhinocladium, Helminthosporium, etc., are often associated with them. According to Guéguen the malady is scarcely ever due to accidental contamination, but is caused by the development, in moist warmth, of moulds already present in the newly manufactured fabric, commercial patterns of the most diverse origin being found almost all to contain fungus spores. Practically all unbleached canvas is affected, but that bleached with hypochlorites, etc., remains free—the glaucous colonies which are sometimes seen are due to Penicillium or Aspergillus derived from the air, and almost invariably non-injurious to the fabric. Guéguen holds that the fungi causing the spots are those which grow on the dead stems of the textile plant, which are introduced amongst the fibres, at the time of retting. The thick-walled hyphæ remain in a resting state in the dry canvas, and resume vegetative growth when external conditions become again favourable (humidity, warm confined air). He considers that the best method

of prevention would be to sterilize the tow after retting, by heat—steam under pressure, and then dry heat. Boiling solutions of salts of chromium or copper would also serve, applied either to the tow or the fabric. A suitable method of rendering awnings, etc., impermeable would be to immerse the fabric first in a 20 per cent. solution of soap, and then in 8 per cent. copper sulphate, each at boiling point.

Similar black spots are very common on paper, and are most commonly due to Alternaria, Stachybotrys, and Chætonium. Sée [" Sur les moisissures causant l'alteration du papier," *Comptes rendus*, vol. CLXIV (1917), p. 230] has investigated the variously coloured spots damaging paper, and believes that the causative fungi are already present in the paper-pulp, and probably come from the straw, fibre, etc., from which the pulp is made.

In the damaged fabrics examined by the writer the perfect Pleospora stage has rarely been found, though the Alternaria and Macrosporium conditions have been frequent. Other Mucedineæ, Cladosporium spp., Stachybotrys, Helminthosporium, etc., were also common. In certain cases fungi were found, however, which seem to be identical with species which are known to occur in the soil. A large number of fungi are active cellulose destroyers ; many of these occur only in the soil, and it seems probable that a large proportion, if not most, of the cellulose destruction which goes on there is brought about by their agency. Canvas left lying about on broken ground would be almost certainly attacked by these cellulose fermenters, given the suitable conditions for growth—a very small portion of soil scattered over moistened sterilized filter-paper gives rise to an amazing number of fungus colonies. Although no experiments have yet been undertaken in connection with this suggestion, it is put forward for certain more or less obvious reasons.

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JAMAICA : GOVERNMENT-AIDED CENTRAL SUGAR FACTORIES.

THE Jamaican Government—or perhaps it would be more accurate to say the Colonial Office—are now fully persuaded of the wisdom of State aid for establishing sugar centrals in Jamaica,

so as to augment considerably the sugar output of that largest of our West Indian possessions. Sir Francis Watts, K.C.M.G., has been touring the island lately and meeting the sugar planters of the various parishes with a view to ascertaining the possibilities ; he has already prepared a scheme for the establishment of Government-aided central sugar factories, and the Legislative Council are being asked to give effect to the proposal. The proposed agreement provides that the cane growers of a given district shall combine amongst themselves under contract to cultivate a sufficient acreage in canes to keep a sugar central in their neighbourhood employed, and shall form a company, the shares of which will be assigned to the Government to be held by the latter as security for the Government interest in the factory, and that on this being done, the Government will advance to the company a sum agreed upon for the erection and working of the factory. The factories schemed for by Sir Francis Watts would have capacities of from 5,000 to 10,000 tons.—[From the *International Sugar Journal*, June, 1917.]

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NEW INDIGO SUBSTITUTE.

NAVY blues always figure very largely in the dyeing industry, and a product like indigo-substitute will doubtless arouse particular interest at present, because it may be applied directly to cotton for the production of deep shades. That in itself suggests less labour, and an additional advantage (writes the *Textile Mercury*) rests in the fact that the dyeing can be accomplished with the minimum consumption of steam. Its first recommendations are, therefore, that it is economical in use and easy of application, as a substitute for indigo, for cotton, linen, and jute. A brochure we have received states that the shades produced are in almost every respect fast colours, since they resist equally well the action of light and of ordinary soaping ; they are affected only by acids. In the operation of dyeing it is necessary to pay some attention to the quality of the water employed.

Should the water used be very calcareous, the colouring matter is likely to be precipitated in the dyeing liquor and lost. To avert this possibility, a water of that quality must be corrected by an

addition of the requisite amount of hydrochloric acid. Subject to these conditions, and that the temperature of the dyeing liquor should not exceed 120 deg. F., the following recipes indicate the methods of working on a large scale :—Direct dyeing : A liquor is prepared containing 2½ oz. of dyestuff to each gallon of water, at a tepid heat, in which the goods are worked for half-an-hour, then removed and washed ; for further lots add to the same liquor 10 lb. of indigo-substitute for each 100 lb. of yarn or material to be dyed. Dyeing on an indigo bottom : The cotton after leaving the indigo vat must be well freed of lime by souring with a solution containing 1½ pints of hydrochloric acid to 200 gallons of water, for 100 lb. of cotton. For that amount of material a liquor is made of 150 to 200 gallons of water and 20 lb. of indigo-substitute, in which the goods are worked for half-an-hour. The dyeing may be carried out in the cold, but a darker shade is obtained by raising the temperature to about 120 deg. F. Operating according to these instructions, the liquor remains perfectly clear, and the amount of colouring matter left is such that for further lots it is necessary to add of indigo-substitute only 10 per cent. of the weight of the cotton to be dyed.

Alternative method of dyeing on an indigo bottom : After bottoming the cotton with indigo sour with dilute sulphuric acid and wring out ; for 100 lb. of cotton make up a liquor with from 10 lb. to 15 lb. indigo-substitute and about 175 gallons of water, and dye for half-an-hour in the cold. This method of working yields a deeper shade of blue, but the bath needs to be fresh for each lot. Dyeing on a logwood bottom : Prepare a liquor with 8 oz. of logwood extract 51 deg. Tw. per gallon of tepid water, and work for about half-an-hour, wring, and dye with indigo-substitute by the method first mentioned. This method gives a dark blue with a coppery overcast, generally known as the Bengal shade.

Dyeing on a sumac and antimony mordant : For 20 lb. of cotton make up a liquor with 4 lb. sumac extract 51 deg. Tw. and 45 gallons of water at 120 deg. F., and manipulate the goods for a few minutes and immerse and leave overnight ; then remove and wring. Next work for twenty minutes in a lukewarm solution of

tartar emetic, 2½ per cent. on the weight of cotton, wash, and dye with indigo-substitute as first mentioned. The resulting shade is a deep and bright blue. Dyeing on a sumac and bluestone mordant: Prepare the cotton with sumac as in the last recipe, and replace the tartar emetic by a corresponding amount of copper sulphate. The resulting shade closely resembles that produced on a sumac and antimony mordant. Indigo-substitute as a bottom for basic dyes: With the basic dyes it acts to a certain extent as a mordant, and when topped with methylene blue full fine shades are obtainable.—[From the *Indiaman*, dated 27th April, 1917.]

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SUPPLY OF NITROLIM.

NITROGEN Fertilizer Companies advertize the fact that they are unable to supply any nitrolim for agricultural purposes for the season 1916-17, as the demand for the product is so insistent that they are obliged to allocate the whole of their output during the continuance of the war. From time to time rumours of projects for manufacturing nitrolim in this country and making use of water power which at present runs to waste have been heard. Nitrolim has undoubtedly found favour with planters to a certain extent, and did experiments show that it was of value for staple like sugar or paddy, there would be a big opening for any such project. Now that the fertilizer cannot be obtained from abroad would seem to be the time to push any such scheme forward.—[*Capital*, June 15, 1917.]

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"PUSA 12."

IT has been the fashion for so long to sneer at India as behind the times in all departments of material activity that we may call attention to a fact, in itself of no great importance, which indicates how she is beginning to forge ahead. Just now there is a well-displayed exhibit of wheat in the windows of the South Australian Government offices in the Strand, and one of the best specimens is marked "Pusa 12," a cryptic label signifying that one at least of the new wheats produced by the Howards at Pusa is considered to be valuable in countries other than that for which they are primarily intended. We hope to hear that its popularity is maintained, and

that India may by and by send out other missionaries of the kind to the great Commonwealth of the South.—[*Indiaman*, June 14th, 1917.]

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INDIAN CATTLE CENSUS.

We extract the following figures regarding live-stock from the *Agricultural Statistics of India*, 1914-15, recently published by the Director of Statistics. These figures are based on cattle censuses which are taken annually in some provinces and quinquennially in others. It is stated that a general census for all provinces will be taken during the year 1919-20.

The total number of cattle in British India is 147,336,000. Of this, bulls and bullocks account for 48,664,710, cows for 37,481,273, buffaloes for 19,025,079, and young stock for 42,184,790.

The following are the provincial figures :—

United Provinces	31,741,000	(22 per cent. of total)
Bengal	25,324,000	(17 ,, ,,)
Madras	21,761,000	(15 ,, ,,)
Bihar and Orissa	20,119,000	(14 ,, ,,)
Punjab	15,489,000	(11 ,, ,,)
Central Provinces and Berar	11,857,000	(8 ,, ,,)
Bombay and Sind	9,677,000	(7 ,, ,,)
Burma	5,882,000	(6 ,, ,,)
Assam	3,576,000	
North-West Frontier Province	1,271,000	
Ajmer-Merwara	351,000	
Delhi	148,000	
Coorg	134,000	
Manpur	6,000	

The number of cattle per 100 acres of cropped area ranges between 32 in Bombay and Sind and 100 in Bengal, while the number per 100 of population ranges between 36 in Delhi and 95 in the Manpur Pargana. The average for British India as a whole is 65 per 100 acres of cropped area and 61 per 100 of population.

The number of sheep is given at 23,015,836 of which Madras possesses 10,765,543 and the Punjab 4,676,899. The number of goats was 33,338,487, horses and ponies 1,653,379, and mules and donkeys 1,512,205. The statistics relating to sheep, goats, horses, and ponies, and mules and donkeys, exclude Bengal, from which no returns regarding these animals are at present received.—[Editor.]

FOOD-PRODUCTS EXHIBITION AT CALCUTTA.

As is well known, the unprecedented difficulties regarding tonnage created by the War have seriously interfered with the normal importation of many articles of food—and in consequence prices have risen enormously. An excellent opportunity has, therefore, presented itself for making known to the public, varieties of food already produced in India but whose existence is unknown to many persons. It is highly desirable that producers and consumers should be put in touch with each other, and that we should try not only to increase our stock of food-products but also to improve our methods of preparation. There are great possibilities of helping the Empire in this way and also of adding to the wealth of this country. It is believed that, if a wider market could be created, the indigenous food trade could be greatly developed. One of the lessons of the War is the desirability of making a country self-supporting, as far as possible, in the matter of food supplies. The first step is to ascertain what the country already contains and with this object in view a Food-Products Exhibition will be held in Calcutta from 1st to 5th January, 1918, under the patronage of Their Excellencies the Governor of Bengal and the Countess of Ronaldshay. A General Advisory Committee has been formed, consisting of the following membeıs to help the Exhibition authorities :—

The Hon'ble Sir Claude Hill, K.C.S.I., C.I.E., I.C.S.
,, ,, Sir Henry Wheeler, K.C.I.E., C.S.I., I.C.S.
,, ,, Maharajadhiraja Bahadur of Burdwan, K.C.S.I., C.I.E., I.O.M.
,, ,, Sir C. W. Chitty, *Kt.*
,, ,, Sir A. Chaudhuri, *Kt.*
,, ,, Sir R. N. Mookerji, K.C.I.E.
Mr. J. Mackenna, C.I.E., I.C.S.
General Strange.
The Hon'ble Sir Stevenson Moore, C.V.O., I.C.S.
,, ,, Mr. J. G. Cumming, C.S.I., C.I.E.
,, ,, Mr. Arden Wood.
Sir Allan Arthur.

H. A. F. Lindsay, Esq., I.C.S.
C. Tindall, Esq., I.C.S.
J. A. Milligan, Esq., I.C.S.
J. Lindsay, Esq., I.C.S.
F. D. Ascoli, Esq., I.C.S.
Dr. Graham.
E. E. Biss, Esq.
The Maharaja Bahadur of Nadia.
The Raja of Tajhat.
Darcy Lindsay, Esq.
Major McCay.
Dr. Hossack.
H. Harris, Esq.
E. Digby, Esq., and others, together with a representative body of Ladies.

Exhibits are invited from firms as well as from private individuals of local food-products of whatever nature. Cereals, tinned foods, ground-rice, flour, sago, tapioca, macaroni, vermicelli, preserved fruits and vegetables; fruits in syrup, dried fruits, jams, jellies, pickles, sauces, essences, cheese, pickled and potted foods of every description; sweets suitable for dessert, etc.

Exhibits will be received immediately and at any time up to December 24, 1917. They should be sent at the risk and expense of the exhibitor, but no fees will be charged for the space provided for exhibits.

We understand that the promoters of the Exhibition are arranging for the services of an expert in food production to test exhibits, where desired, and to advise as to better or extended production.

Suggestions are invited as to substitutes for imported goods; as to methods of preparing local fruits and vegetables; or local cereals for infant and invalid foods; and as to the improvement of foods, oils, essences, etc., locally manufactured.

Exhibits and suggestions should be addressed to the Honorary Secretary (Exhibits or Suggestions, as the case may be), Food-Products Exhibition, Commerce and Industry Building, 1, Council House Street, Calcutta.—[EDITOR.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

THE services of Mr. F. Noyce, I.C.S., have been placed temporarily at the disposal of the Government of India, Department of Revenue and Agriculture.

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Mr. A. HOWARD, C.I.E., M.A., Imperial Economic Botanist, and Mrs. G. L. C. Howard, M.A., Second Imperial Economic Botanist, have been granted privilege leave for 33 days with effect from 9th September, 1917.

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MR. F. M. HOWLETT, B.A., Imperial Pathological Entomologist, returned from the combined leave granted to him, and resumed charge of his duties on 27th August, 1917.

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MR. WYNNE SAYER, B.A., Assistant to the Agricultural Adviser to the Government of India, was granted privilege leave for one month and he availed himself of it with effect from 3rd September, 1917.

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MR. A. W. SHILSTON, M.R.C.V.S., Assistant Bacteriologist, Muktesar, is confirmed in his appointment with effect from the 20th March, 1917. His designation has been changed to Second Bacteriologist.

Mr. Shilston left on the 15th June, 1917, on deputation to Basra, to investigate lymphangitis simulating glanders among horses, and also biliary fever which is prevalent.

LIEUTENANT E. C. BOWES, Army Veterinary Corps (Special Reserve), has been appointed to officiate as Assistant Bacteriologist, Imperial Bacteriological Laboratory, Muktesar, with effect from the afternoon of the 15th June, 1917.

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THE GOVERNMENT OF MADRAS have appointed Dr. Marsden, the Government Dyeing Expert, as Special Indigo Research Officer for a period of one year in the first instance. He is to undertake the investigation of methods of manufacture by the ryots with a view to suggest improvements and reduce adulteration. He is to work in close collaboration with Mr. W. A. Davis, B. Sc., Indigo Research Chemist, Pusa.

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THE services of Mr. Roger Thomas, B.Sc., Deputy Director of Agriculture, VI Circle, Madras, have been temporarily placed at the disposal of the Government of India in the Foreign and Political Department for deputation to Mesopotamia in connection with cotton experimental work in that country. Mr. Hugh Charles Sampson, B.Sc., Deputy Director of Agriculture, V and VII Circles, will hold charge of the VI Circle in addition to his own duties during the absence of Mr. Thomas, or until further orders.

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M. R. RY. M. GOVINDA KIDAVU AVERGAL has been appointed to the post of Assistant Director of Agriculture, VII Circle, with headquarters at Tellicherry, Malabar.

***

DR. W. H. HARRISON, Government Agricultural Chemist, Coimbatore, was granted privilege leave for one month last July. During his absence M. R. Ry. M. R. Ramswami Sivan, the Senior Assistant in Chemistry, was appointed to act as Government Agricultural Chemist.

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MR. R. CECIL WOOD, M.A., Principal of the Agricultural College and Research Institute, and Professor of Agriculture and Superin-

tendent of the Central Agricultural Station, Coimbatore, was granted privilege leave from 8th September to 1st October, 1917. During the absence of Mr. Wood, Dr. W. H. Harrison, Government Agricultural Chemist, was appointed to be in charge of the office of the Principal of the Agricultural College, and M. R. Ry. D. Ananda Rao Garu, Assistant Principal and Assistant Professor of Agriculture to act as Professor of Agriculture and Superintendent of the Central Agricultural Station in addition to his own duties.

***

MR. F. R. HEMINGWAY, I.C.S., has been appointed Registrar of Co-operative Societies in the Madras Presidency in succession to Dewan Bahadur L. D. Swamikannu Pillai who reverts to the general line as Magistrate and Collector.

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MR. C. G. LEFTWICH, I.C.S., Director of Agriculture and Industries, Central Provinces, is placed on special duty in the Secretariat, Nagpur.

He is also appointed Controller of Munitions, Central Provinces and Berar Circle, under the Indian Munitions Board, in addition to his other duties.

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MR. F. J. PLYMEN, A.C.G.I., Agricultural Chemist, Central Provinces and Berar, has been appointed Staff Captain, 5th (Mhow) Division, in connection with the Indian Defence Force.

***

MR. G. EVANS, M.A., Deputy Director of Agriculture, Northern Circle, Central Provinces, is placed on special duty under the Chief Recruiting Officer, Central Provinces and Berar, and Secretary, Central Provinces War Board, with effect from the date on which he may be relieved of his duties.

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MR. NAND KISHORE, Extra Assistant Director of Agriculture, Jubbulpore, is appointed to hold charge of the current duties of the office of the Deputy Director of Agriculture, Northern Circle,

in addition to his own duties, during the absence of Mr. Evans on special duty, or until further orders.

***

MR. J. T. DONOVAN, I.C.S., has been appointed to act as Registrar of Co-operative Societies, Bengal, in place of Rai Jamini Mohan Mitra Bahadur appointed Assistant Secretary, Government of India, Education Department.

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MR. M. M. MACKENZIE, Superintendent, Sepaya Farm (Bihar), was granted privilege leave for one month and four days with effect from the 3rd September, 1917, or any subsequent date on which he might avail himself of it.

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MR. D. QUINLAN, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bihar and Orissa, was allowed privilege leave for one month and seven days with effect from the 2nd June, 1917.

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THE HON'BLE MR. C. A. H. TOWNSEND, B.A., I.C.S., Director of Agriculture and Industries, Punjab, is appointed Controller of Munitions, Punjab Circle, under the Indian Munitions Board, in addition to his own duties.

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LIEUTENANT-COLONEL J. FARMER, C.I.E., F.R.C.V.S., Chief Superintendent, Civil Veterinary Department, Punjab, is promoted to the rank of Colonel.

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THE services of Mr. H. E. Cross, M.R.C.V.S., Camel Specialist, Punjab, as well as of his office, have been temporarily transferred to the Army Department with effect from 15th June, 1917.

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MR. T. COUPER, I.C.S., Officiating Director of Agriculture, Burma, is confirmed in the appointment of Director of Agriculture with effect from the 1st April, 1917.

MR. H. CLAYTON, I.C.S., Officiating Registrar of Co-operative Societies, Burma, is confirmed in the appointment of Registrar of Co-operative Societies with effect from the 1st April, 1917.

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* *

MAUNG BA GYAW, temporary Engineer in the Public Works Department, Burma, whose services have been transferred to the Agricultural Department, Burma, is appointed as an Agricultural Engineer in that department for a period of one year, with effect from the 17th May, 1917, with headquarters at Mandalay.

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* *

MAJOR G. K. WALKER, C.I.E., F.R.C.V.S., Superintendent, Civil Veterinary Department, Bombay Presidency, is promoted to the rank of Lieutenant-Colonel.

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THE degree of D. Sc. in Botany has been conferred by the University of St. Andrews on Mr. R. J. D. Graham, M.A., B.Sc., Economic Botanist, Central Provinces.

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* *

THE GOVERNMENT OF MADRAS have approved the proposal of the Director of Agriculture that successful diplomates of the Coimbatore Agricultural College should in future be placed in two classes, those passing the diploma examination with signal merit being placed in the first class. In this connection the College Board has resolved that the word " Honours " should be reserved for future extension of the curriculum. No such classification was found necessary for those gaining the " Proficiency Certificate " as those showing particular merit would naturally be selected for the diploma course.

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* *

IN December, 1916, the Commissioner in Sind requested the administrative approval of Government to the establishment of a cattle farm in the vicinity of Karachi at an estimated capital cost of from Rs. 30,000 to Rs. 40,000 and an annual recurring expenditure of Rs. 10,000 and that orders might be issued to the Public Works

Department to prepare the plans and estimates for the necessary buildings. Seth Chellaram Dallumal had contributed Rs. 15,000 which would reduce the capital cost to a maximum of Rs. 25,000. The Commissioner requested that this amount be provided in the budget estimates for the ensuing year, together with a sum of Rs. 10,000 to meet the estimated recurring expenditure. The Government of Bombay have now issued an order stating that administrative approval is accorded to the establishment of the farm.

***

IT is notified that the provisions of the Dourine Act, 1910, are extended to the whole of the Punjab. A committee is to be constituted in each division of the Punjab for the purpose of hearing appeals under section 11 of the Act. Each committee will consist of the Commissioner of the Division, a veterinary practitioner to be nominated by the Commissioner, and an Indian gentleman, not in the employment of Government or a local authority to be selected on each occasion by the Deputy Commissioner of the district in which the appellant resides.

***

THE fifth annual meeting of the Indian Science Congress will be held in Lahore on the 9th, 10th, 11th, and 12th January, 1918. His Honour the Lieutenant-Governor of the Punjab, Sir Michael O'Dwyer, G.C.I.E., K.C.S.I., has consented to be Patron of the meeting, and Dr. G. T. Walker, C.S.I., F.R.S., Director-General of Observatories, will be President. The following Sectional Presidents have been appointed :—

Agriculture : L. C. Coleman, Esq., M.A., Ph.D., Director of Agriculture, Mysore State.

Physics and Mathematics : Wali Mahomed, Esq., B.A., Ph.D., Professor of Physics, Mahomedan Anglo-Oriental College, Aligarh.

Chemistry : Dr. G. J. Fowler, Bangalore.

Zoology and Ethnology : B. L. Chaudhuri, Esq., B.A., D.Sc., F.R.S.E., F.L.S., Calcutta.

Botany: R. S. Hole, Esq., F.C.H., F.L.S., Forest Botanist, Forest Research Institute and College, Dehra Dun.

Geology: E. S. Pinfold, Esq., Rangoon.

Dr. J. L. Simonsen, Professor of Chemistry, Presidency College, Madras, will be General Secretary, and Professor A. S. Hemmy and Rai Saheb Ruchi Ram Sahni, Government College, Lahore, will be Local Secretaries.

***

THE Government of Bengal has made a grant of Rs. 10,000 to Miss Cleghorn to continue her research relating to silk rearing. She has obtained a multivoltine hybrid race which is already in its 42nd generation. It is reported that this hybrid in a trial last year gave 36 per cent. better produce than the indigenous race.

***

SINCE the publication of the list in the last July number of this Journal the following Veterinary Assistants have been temporarily employed on military duty :—

(1) S. hakravarti
(2) P. C. Bhattacharji
(3) M. P. Pillai
} From Bihar and Orissa.

(4) Syed Hadi Hussain Naqui
(5) Pardaman Singh
} From the Central Provinces.

Reviews.

The Bombay Co-operative Quarterly, Vol. I, No. 1 (issued by the Bombay Co-operative Library). Annual subscription, Rs. 2. Single copy, As. 8.

WE extend a hearty welcome to this new quarterly. It opens with a foreword by the Hon'ble Sir Claude Hill who points out that the aim of the co-operative movement should be twofold, namely, (1) the reduction and extinction of that indebtedness which has been the bane of India's economic history, and (2) the provision of facilities for improvement and development by the pooling of resources. Sir Claude points out that, the Servants of India apart, there has hitherto been less unofficial aid to the movement than might have been hoped for; and it is for this reason that Government as well as the public will, he feels confident, welcome the appearance of this periodical.

This first number contains an interesting account of co-operative societies for the sale of cotton in the Southern Maratha Country by the Hon'ble Mr. Keatinge, a perusal of which we would commend to all Deputy Directors of Agriculture. Mr. Crosthwaite supplies some very readable recollections and reflections of the twenty years during which he has been connected with the co-operative movement.

In a paper on the rate of co-operative progress in different parts of India Mr. R. B. Ewbank gives a thoughtful analysis of this progress so far as it can be judged by statistics. The diffusion of co-operative knowledge and the extent to which co-operative principles have been generally assimilated are no doubt factors even more important than any of those mentioned (*i.e.*, number of members, the number of societies, capital, and disbursements as the

four fundamental facts of progress), but it is scarcely possible to gauge precisely moral progress of this sort, and though the statistical tables afford some material for conjecture, no definite conclusion can be arrived at. If we take the four factors quoted as a reasonable form of progress we get the following results, bearing in mind that the number of societies is for instance a trustworthy criterion only when it is considered in relation to the area of the province, the population, the average number of members per society, and the average capital.

The Punjab heads the list in total number of societies (3,337), number of societies per lakh of population (16·7), and number of societies per 1,000 sq. miles (33·3), but it falls to sixth place in the average membership of society which is only 47 as against Bombay where it is 103. Bombay also heads the list of working capital per society which is Rs. 9,775. From these figures Mr. Ewbank points the conclusion that the thinly populated provinces have far more societies in proportion to their population than the densely populated provinces, but as might be expected these societies are on the whole much smaller in members and capital.

As regards working capital the Punjab again comes first as regards the total (Rs. 2,05,63,000) but has only Rs. 139 working capital per member as against Rs. 221 in Burma which has a total working capital of only about half what the Punjab has, *viz.*, Rs. 1,03,39,000. Similarly the working capital in agricultural primary societies is Rs. 130 per head in Burma as against Rs. 105 in the Punjab. The Punjab also heads the list in the amount of deposits in agricultural societies and in the total reserve fund, while Bombay leads in the amount of deposits by members.

Departing from the complex method of statistical estimate Mr. Ewbank lays down as the three main conditions of rapid progress—

(1) a keen demand for cheaper credit for agriculture;

(2) an educated peasantry, or, failing that, strong educating and supervising agencies to control societies;

(3) an organization which can ensure to village societies prompt and adequate finance.

To that he adds a fourth condition: an experienced and sufficient controlling staff.

Mr. M. H. Desai gives an interesting account of co-operation in Gujarat.

We congratulate the Bombay Co-operative Library on the first issue of its journal and trust it will have the circulation which its merits deserve, amongst those interested in co-operation and economic development in India.—[J. M.]

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The Law and Principles of Co-operation in India.—By H. CALVERT, I.C.S. Published by Thacker, Spink & Co. Price Rs. 4.

THIS book strikes out a somewhat new line in the literature of Co-operation and brings the Co-operative Societies Act, 1912 (II of 1912), into the Library of annotated Acts. In view of the very general style in which co-operative questions are frequently written about, it is perhaps as well that we should be reminded that if co-operation is a great economic factor, the application of its principles must follow the rigid provisions of law. As Mr. Calvert remarks, the first point of importance to be noted about the Act is that it is a modified Code of Company Law and so necessitates the strictest adherence to rules and by-laws. He therefore insists that the rules which have been based on English experience adapted to Indian conditions should be rigidly observed. "Nothing could be more detrimental to the progress of co-operation than the idea that it is compatible with sloppiness. The problem to be grappled with is largely that of rural finance and sloppy finance is intolerable." While, therefore, the movement may originate in a semi-philanthropic economic spirit and while this spirit will undoubtedly be a great driving force in the formation and stimulation of societies, once the society has been formed it must conform most rigidly to the usual legal restrictions on associations of a business character or on ordinary banks.

In the light of the experience gained both in England and in India, Mr. Calvert proceeds to the annotation of the Act, his aim being to assist in the solution of the many questions that daily

require answering in the work of primary societies. It attempts to show what has been done elsewhere and so to provide in convenient form what should be known to all engaged in the co-operative movement. In this aim we consider Mr. Calvert has succeeded and his annotated Act will, we feel sure, be of considerable assistance to Registrars and co-operative organizers as well as to any law officials who may—but this will be rare—have to interpret the Act.—[J. M.]

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We have received a copy of a pamphlet entitled "**Madras Agriculture—A Brief Survey,**" issued by the Department of Agriculture, Madras, and we welcome this publication as giving a brief description of the outstanding features of Madras Agriculture and a detailed account of the agricultural products of the Presidency. Though two years have elapsed since the holding of the exhibition at which these products were exhibited the facts given in this pamphlet have not lost any interest on that account. On the other hand we consider that the facts and general observations recorded therein will continue to prove useful both to the trade and the general public for some more years to come.

Madras differs from the whole of the rest of India in that it lies entirely within the tropics. Wheat and red gram, two of the important crops of Northern India, hold there an altogether subordinate position. Rice, millets, and truly tropical oilseeds, *e.g.*, copra and groundnut, predominate. Excluding Feudatory States the total cropped area in Madras is 35 million acres. Of this 10 per cent. is cropped more than once in a year which means that for all practical purposes we can take 39 million acres as the total cultivated area of the presidency. This supports a population of 41½ millions which gives per head of population a cultivated area somewhat under an acre. In spite of this the Presidency is self-supporting in normal years. This is not to be wondered at when we take the case of Japan which in 1872 was able to feed herself though the average per head of population there was only 0·3 acre of cultivated area. The Japanese peasantry made up for the small size of

their holding by high farming and most careful preservation and application of manures. The Madrassi cultivator though not coming up to the Japanese in point of farming skill has a slightly larger average arable area to make up this deficiency.

The trend of the agriculture of the Presidency is towards expansion of the area under cultivation and the substitution of more paying crops. Rice occupies over 10½ million acres out of the total of 39 million and the yield is over 8 million tons worth roughly about 85 crores of rupees. The area under this crop has increased as the result of the construction of large irrigation works with extensive canal systems. The increase in groundnuts and cotton is substantial. Groundnut occupies nearly 2 million acres with an approximate money value of Rs. 8,00,00,000. The export trade in groundnut and its products increased from Rs. 181 lakhs in 1903 to 503 lakhs in 1913. The total area under cotton is over 2 million acres, the out-turn valued at Rs. 7,00,00,000. The number of spindles in local mills increased from 250,352 in 1894-95 to 422,068 in 1914-15. The local consumption of cotton in these mills increased from 28 million pounds to 42 million pounds in the same period.

It would make this review unnecessarily lengthy if we were to give statistics regarding the valuable planters' crops grown in this Presidency. For these we would refer the reader to the publication itself. The paragraphs on general land economics, distribution of holdings, land tenures, landlord and tenant, prices of land, labour, etc., though necessarily sketchy, still give valuable statistical and other information, while the details given about food and commercial crops ought to prove useful to those for whom they are intended. To those primarily interested in the agricultural aspect of the problem a perusal of this pamphlet brings home the conviction that the ryots are winning more and more produce from the land and the general rise in the value of agricultural produce is improving their economic position. This will, it is hoped, considerably help the Agricultural Department in its work of still further improving the local agriculture.—[EDITOR.]

Expenses and Profits of Cultivators in the Punjab.—By W. S. HAMILTON, I.C.S. (Lahore: Superintendent, Government Printing, Punjab.)

THIS is an extremely valuable compilation by Mr. W. S. Hamilton, I.C.S., late Director of Agriculture and Industries in the Punjab. Mr. Hamilton's estimates are based on inquiries into actual practice. The tables have been drawn up as opportunities offered on tour, and the answers of the villagers noted down as they and the author sat and talked beside the village well. The main investigations were carried out in a Jat village in the Lyallpur District, Tarn-Taran Tahsil (Amritsar District), Shakarpur Tahsil, Gujranwala Tahsil, and Gurdaspur Tahsil, and the crops dealt with were wheat, cotton, sugarcane (crushing cane), and chewing cane. The profits on an acre of well-irrigated wheat work out at Rs. 29-4 in Gujranwala and Rs. 37-3 in Shakarpur, on canal-irrigated land in Tarn-Taran at Rs. 50-6; while in a Jat village in Lyallpur District, where it is not stated whether the irrigation is carried out by well or canal, at Rs. 37-13-6, the average yield being estimated at 20 maunds of grain and 40 maunds of straw. A canal-irrigated acre of cotton in Tarn-Taran yields Rs. 58-0 and the profits of a Lyallpur Jat per acre of cotton amount to Rs. 42-9-6. The two canal-irrigated villages in Gurdaspur District, where the *Katha* and *Dhaulu* varieties of sugarcane are grown, show profits of Rs. 39-4 and Rs. 50 per acre respectively. This big difference is explained by the fact that the feed and keep of a pair of bullocks cost Rs. 161-14 per annum in the former village and only Rs. 89 in the latter. The thick *Pounda* cane, which is sold for chewing, is more profitable than *Dhaulu* or *Katha*, yielding a net profit of Rs. 69 per acre to the cultivators of Hansi. It will be noticed that these figures are much higher than those of Settlement Officers, but Mr. Hamilton explains that his tables deal with a normal crop—the crop a cultivator expects to gather in an ordinary year—while Settlement Officers must, in order to guard against crop failures, take as their standard the average crop. It is evident from Mr. Hamilton's figures that the cost and maintenance of his plough cattle is the heaviest burden which the cultivator has to bear. The cost of feeding a pair of bullocks varies considerably in the different villages; in part of Gurdaspur it amounts to Rs. 161-14

while in part of Gujranwala it is as low as Rs. 61-8. Mr. Hamilton finds it difficult to reconcile these figures completely.

It is to be specially noted that Mr. Hamilton's figures refer only to lands which are served either by canals or wells and to years when there are no special calamities for the farmer such as drought or floods or hail or cotton boll-worm. The one word of criticism that we have to pass is that in calculating the cost of cultivation Mr. Hamilton has charged nothing for the labour which the zamindar himself and his family contribute to the raising of the crop. In order to arrive at net profits it is necessary that the value of such labour should be included in cultivation charges, but the difficulty of estimating for this is well known to all Settlement Officers.—[EDITOR.]

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Agricultural Calendar, 1917-1918. (Madras Agricultural Department.) Price 1 anna.

THE English edition of the Agricultural Calendar published by the Madras Agricultural Department, for the year 1917-18, maintains the high standard of its previous issues. It opens with an article on the aims and purpose of the Agricultural Department by Mr. D. T. Chadwick, lately Director of Agriculture, Madras, who explains in a lucid and convincing manner how greatly the ryots in the Madras Presidency have profited by the activities of the Department. To take only one crop—cotton—in the districts of Tinnevelly, Kurnool, and Bellary, there were last year over 36,000 acres under better kinds of cotton, the seed of all of which had originally been issued from the Government Agricultural Stations. Cambodia cotton, which is now very common throughout the southern districts and has proved very profitable to many ryots, was first chiefly tested and tried at Government farms. The introduction of the Sircar strain of cotton has been equally successful in the black cotton soils of Bellary and Kurnool. It yields as heavily as the local cotton but gives a very much higher ginning out-turn—30 per cent. against the local 26 per cent. The calendar proper, which gives the dates of cattle fairs, cattle shows, and agricultural exhibitions, besides other useful information, is sandwiched between articles by several experts of the Department on their respective subjects. A brief

summary of the more important things which can be seen at the Government Agricultural Stations together with the times most suitable for visiting them is also given. Among other useful notes we may mention those describing the symptoms and remedies of the common ailments of cattle; the benefit to be derived from the use of specially designed implements like the Monsoon Plough of Messrs. Ransome, Sims, and Jeffries; the concessions the Government are willing to give by foregoing *fasal jasti* or water rate for the growing of green manure or fodder, not for sale, but for legitimate use by the growers; and the rules for special loans to ryots for erecting pumping installations. The price of the Calendar is only one anna, and it is difficult to conceive where else the Madras cultivator can get so much valuable information at so cheap a price.—[EDITOR.]

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A Note on the Action of Purgatives on the Camel.—By H. E. CROSS, M.R.C.V.S., D.V.H., A.Sc. 6pp. (Lahore: Superintendent, Government Printing, Punjab.)

MR. CROSS, Camel Specialist to the Government of the Punjab, Sohawa, has embodied in this booklet the results of his experiments regarding the action of various purgatives on the camel. The interest of these results is enhanced by the fact that no experiments of the kind have previously been carried out on the camel and nothing is known regarding the doses of various purgatives that are tolerated. The author tested the following purgatives and recommends the doses mentioned below:—

Eight ounces Kamala *(Mallotus philippinensis)* in linseed tea given as a drench; 4 pints linseed oil; 3½ drachms croton oil in linseed tea; 3½ ounces aloes dissolved in water; 1½ to 2 pounds magnesium sulphate; 3 ounces powdered gamboge; and two grains of eserine and two grains of pilocarpine dissolved in 80 minims of water and injected subcutaneously. Of these the best has been found to be magnesium sulphate; the others come in the following order: *Kamala*, croton oil, aloes, gamboge, and linseed oil. Hypodermic injections of eserine and pilocarpine in doses of 2 grains each also give very satisfactory results.—[EDITOR.]

WE have received a finely got up and profusely illustrated booklet giving particulars of **Queen Mary's Technical School for Disabled Indian Soldiers** which has been established in Bombay through the efforts of Her Excellency Lady Willingdon, C.I., with the view of taking over for a period of six months or more disabled soldiers and followers of the Indian Army of all ranks and classes and teaching them a trade, so that after a course of training they will have means of supplementing their pensions and will be able to live in comfort. Those who join the Institute are provided with clothes, bedding, food, etc., free, and if a man joins from up-country he is given a return railway ticket and travelling expenses. We are glad to notice that, among other things, instruction is given in agriculture, and poultry farming. We are told that the grounds of the School afford excellent opportunities for teaching the elements of agriculture and that the cultivation of crops, fruit, vegetables, etc., on modern principles is taught. When it is remembered that the recruits for the Indian Army are mainly drawn from the peasant proprietors of the Punjab, the Deccan, etc., these two branches of the School ought to prove popular with the sepoys. The School is under the patronage of Their Majesties, and it is not too much to hope that it will receive the generous support of the princes and people of India.—[EDITOR.]

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WE have received the following books from the Director of the Chilean Nitrate Propaganda, Agency Calcutta :—

Soil Fertility and Crop Production.
Guide to Manuring of Field and Garden Crops.
Leaflets on manuring.

These are well got up and nicely produced. They deal with the advantage of manuring with nitrate of soda and will no doubt be read with interest especially on tea plantations and where there is possibility of the utilization of nitrate of soda.—[G. S. H.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

1. The Rare Earths: Their Occurrence, Chemistry, and Technology, by S. I. Levy. With Introduction by Sir William Crookes. Pp. 359. (London: Edwin Arnold.) Price 10*s*. 6*d*. net.

2. Tropical Agriculture, by Dr. E. V. Wilcox. Pp. xviii + 373. (New York and London: D. Appleton & Co.) Price 10*s*. 6*d*. net.

3. Science and the Nation. Essays by Cambridge Graduates with an Introduction by Lord Moulton. Edited by A. C. Seward. (Cambridge University Press.) Price 5*s*. net.

4. Nature Study Lessons: Seasonally Arranged, by J. B. Philip. With 23 Illustrations. Price 2*s*. 6*d*. net.

5. A Handbook of Organic Analysis: Qualitative and Quantitative, by H. T. Clarke. With an Introduction by Professor J. Norman Collie. Pp. viii + 264. Price 5*s*. net.

6. An Introduction to the Chemistry of Plant Products, by Paul Haas and T. G. Hill. With Diagrams. Second Edition. (London: Longmans, Green & Co.) Price 10*s*. 6*d*. net.

7. Microbiology: A Text-Book of Micro-Organisms, General and Applied, edited by C. E. Marshall. New (second) Edition. 186 Illustrations. (London: J. & A. Churchill.) Price 12*s*. 6*d*. net.

8. Bloxam's Chemistry: Inorganic and Organic, by A. G. Bloxam and S. Judd Lewis. Tenth Edition. With 313 Illustrations. (London: J. & A. Churchill.) Price 21*s*. net.

9. Ozone: Its Manufacture, Properties, and Uses, by Dr. A. Vosmaer. Pp. xii + 197. (London: Constable & Co.) Price 10*s*. 6*d*. net.
10. Some Compounds of Boron, Oxygen and Hydrogen, by M. W. Travers, N. M. Gupta, and R. C. Ray. (London: H. K. Lewis & Co., Ltd.) Price 1*s*. net.
11. Studies of Inheritance in Guinea-pigs and Rats, by W. E. Castle and Sewall Wright. Pp. 192 + 7 plates. (Carnegie Institution of Washington.)
12. Technical Chemists' Handbook: Tables and Methods of Analysis for Manufacturers of Inorganic Chemical Products, by D. George Lunge. Second Edition, Revised. Pp. xvi + 264. (London: Gurney and Jackson.) Price 10*s*. 6*d*. net.
13. A Text-Book of Quantitative Chemical Analysis, by Drs. A. C. Cumming and S. A. Kay, Second Edition. Pp. xv + 402. (London: Gurney and Jackson.) Price 9*s*. net.
14. Plants of the Punjab: A Descriptive Key to the Flora of the Punjab, North-West Frontier Province, and Kashmir, by C. J. Bamber, M.V.O., Colonel, Indian Medical Service. (Lahore: Government Press.) Price Rs. 5.
15. Algae: Vol. I, Myxophyceæ, Peridinieæ, Bacillarieæ, Chlorophyceæ, together with a brief summary of the occurrence and distribution of Fresh-water Algae, by Professor G. S. West. (Cambridge Botanical Handbooks.) Pp. viii + 475. (Cambridge: At the University Press.) Price 25*s*. net.
16. The Anthocyanin Pigments of Plants, by Muriel Wheldale. Pp. x + 318. (Cambridge: At the University Press.) Price 15*s*. net.
17. The Borderlands of Science, by Dr. A. T. Schofield. Pp. viii + 255. (London: Cassell & Co., Ltd.) Price 6*s*. net.
18. The Pruning Manual, being the Eighteenth Edition, Revised and Reset of the *Pruning Book*, which was first published in 1898, by L. H. Bailey. Pp. xiii + 407. (New York: The Macmillan Co.; London: Macmillan & Co., Ltd.) Price 8*s*. 6*d*. net.

19. Reports of the Progress of Applied Chemistry, issued by the Society of Chemical Industry. Vol. I, 1916. Pp. 335. (London: Harrison & Sons.)
20. The Theory of Evolution with Special Reference to the Evidence upon which it is founded, by William B. Scott, Ph.D., Hon. D.Sc., LL.D. (London: Macmillan & Co.) Price 4*s*. 6*d*. net.
21. A Short History of Sugar, 1856—1916: A Warning, by George Martineau, C. B. Pp. 85. British Empire Producers' Association. Price 1*s*. net.
22. Food and Fitness: or Diet in Relation to Health, by James Long. Pp. ix+208. (London: Chapman and Hall, Ltd.) Price 5*s*. net.
23. The Potato, by Arthur W. Gilbert, Ph.D., assisted by M. F. Barrus and Daniel Dean. Illustrated. (London: Macmillan & Co.) Price 6*s*. 6*d*. net.
24. British Insects and How to Know Them, by H. Bastin, Pp. ix+129+12 plates. (London: Metheun & Co., Ltd.) Price 1*s*. 6*d*. net.
25. Field Crops for the Cotton-Belt, by Professor J. O. Morgan. Pp. xxvi+456. (New York: The Macmillan Co.; London: Macmillan & Co., Ltd.) Price 7*s*. 6*d*. net.
26. The Organization of Thought: Educational and Scientific, by Prof. A. N. Whitehead. Pp. vii+228. (London: Williams & Norgate.) Price 6*s*. net.
27. Productive Dairying, by R. M. Washburn. Price, Rs. 7-8.
28. Surface Wells in Sandy Strata, by F. C. Temple, M.I.M.E., M.R.S.I., Sanitary Engineer to the Government of Bihar and Orissa. Price R. 1.
29. Herbert Spencer, by Hugh Elliot. (London: Constable & Co.) Price 6*s*. net.
30. Elements of Earth Boring for Water, by K. Narayana Iyenger, B.A., L.C.E., Technical Superintendent, Sanitary Engineers' Branch, Madras, P. W. D. Illustrated. Price R. 1.

The following Memoirs of the Department of Agriculture in India have been published since our last issue :—

Orobanche as a Parasite in Bihar, by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S. (Botanical Series, Vol. IX, No. 3.) Price R. 1 or 1*s*. 6*d*.

Indian Sugarcane Leaf-hopper (*Pyrilla aberrans*, Kirby), by C. S. Misra, B.A. (Entomological Series, Vol. V, No. 2.) Price Rs. 2 or 3*s*.

Report on a Collection of Termites from India, by Karin and Nils Holmgren, Högskolas Zootomiska Institut, Stockholm, translated by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. (Entomological Series, Vol. V, No 3.) Price R. 1 or 1*s* 6*d*.

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LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1st FEBRUARY, 1917, TO 31st JULY, 1917.

No.	Title	Author	Where published
	GENERAL AGRICULTURE.		
1	The *Agricultural Journal of India*, Vol. XII, Parts II and III. Price Rs. 2; annual subscription Rs. 6.	Issued from the Agricultural Research Institute, Pusa.	Messrs. Thacker, Spink and Co., Calcutta.
2	Special Indian Science Congress Number of the Agricultural Journal of India. Price Rs. 2, or 3*s*.	Ditto ...	Ditto.
3	Annual Report of the Board of Scientific Advice for India for the year 1915-16. Price R. 1, or 1*s*. 10*d*.	Issued by the Board of Scientific Advice for India.	Government Printing, India, Calcutta.
4	Agricultural Statistics of India, 1914-15, Vols. I and II. Price Rs. 2-8 and R. 1, respectively.	Issued by the Department of Statistics, India.	Ditto.
5	Estimates of Areas and Yields of Principal Crops in India, 1915-16. Price As. 8.	Ditto ...	Ditto.
6	Leaflet No. 1 of 1917: Castor Cake.	F. Smith, B.SC., F.H.A.S., M.R.A.S.E., Deputy Director of Agriculture, Western Circle, Bengal.	Department of Agriculture, Bengal.
7	Leaflet No. 2 of 1917: Indrasail Paddy.	R. S. Finlow, B.SC., F.C.S., Fibre Expert to the Government of Bengal.	Ditto.
8	*Krishi Samachar*, or Year Book of the Department of Agriculture, Bengal (in Bengali) for 1322 B.S. Price As. 8.	Department of Agriculture, Bengal.	Ditto.
9	Season and Crop Report of Bengal for 1916-17. Price R. 1-5, or 2*s*.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book-Depôt, Calcutta.
10	Season and Crop Report of Bihar and Orissa for 1916-17.	Issued by the Department of Agriculture, Bihar and Orissa.	Bihar and Orissa Government Press, Patna.
11	Agricultural Statistics of Bihar and Orissa for 1915-16.	Ditto ...	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
12	Report on the Agricultural Station, Orai (Jalaun), for the year ending 30th June, 1916.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
13	Annual Report of the Lawrence Gardens for 1916-17. Price As. 2.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
14	Annual Report of Jalgaon Agricultural Station (Seed Farm), for 1915-16. Price As. 10, or 1*s*.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
15	Annual Report of Gokak Canal Agricultural Station for 1915-16. Price As. 13, or 1*s*. 3*d*.	Ditto ..	Ditto.
16	Annual Report of Gadag Agricultural Station for 1915-16. Price As. 10-6, or 1*s*.	Ditto ..	Ditto.
17	Annual Report of Dharwar Agricultural Station for 1915-16 Price As. 10-6, or 1*s*.	Ditto ..	Ditto.
18	Annual Report of Alibag Agricultural Station for 1915-16. Price R. 1, or 1*s*. 6*d*.	Ditto .	Ditto.
19	Annual Report of Ratnagiri Agricultural Station for 1915-16. Price As. 13-3, or 1*s*. 3*d*.	Ditto ...	Ditto.
20	Annual Report of Mirpurkhas Agricultural Station for 1915-16. Price As. 5-9, or 7*d*.	Ditto ...	Ditto.
21	Annual Report of Landhi Agricultural Station for 1915-16. Price As. 6 6, or 7*d*.	Ditto ...	Ditto.
22	Annual Report of Larkhana Agricultural Station for 1915-16. Price As. 4, or 5*d*.	Ditto ...	Ditto.
23	Annual Report of Sukkur Agricultural Station for 1915-16. Price As. 6, or 6*d*.	Ditto ..	Ditto.
24	Annual Report of Ganeshkhind Gardens Agricultural Station for 1915-16. Price As. 4-3, or 5*d*.	Ditto ...	Ditto.
25	Annual Report of the Agricultural College Dairy, Kirkee, for 1915-16. Price As. 3.	J. B. Knight, Professor of Agriculture.	Ditto.
26	List of seeds available on the Agricultural College Farm, Poona. Bulletin No. 80 (1916) of the Department of Agriculture, Bombay. Price As. 5-3, or 6*d*.	V. G. Gokhale, Superintendent, Agricultural College Farm, Poona.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
27	Note on Fencing Construction. Bulletin No. 81 of 1916 of the Department of Agriculture, Bombay. Price As. 6-9, or 7*d*.	T. Gilbert, Deputy Director of Agriculture, Southern Division.	Government Central Press, Bombay.
28	Cultivation of drilled paddy in South Bombay Presidency, Bulletin No. 82 of 1916 of the Department of Agriculture, Bombay. Price As. 8, or 9*d*.	T. Gilbert and S. S. Salimath.	Ditto.
29	Seed selection Series II, Kumpta Cotton. Bulletin No. 84 of 1917 of the Department of Agriculture, Bombay. Price Anna 1, or 2*d*.	G. L. Kottur, Cotton Supervisor, S. D. Dharwar.	Ditto.
30	Leaflet No. 1 of 1917 : 'Guinea grass.	R. Cecil Wood, M.A., Principal, Agricultural College, Coimbatore.	Government Press, Madras.
31	Leaflet No. 2 of 1917 : 'Lucerne.'	Ditto ...	Ditto.
32	Leaflet No. 4 of 1917 : 'Possible Improvements in the Manufacture of Indigo in the Madras Presidency.'	C. A. D. Stuart, I.C.S., Director of Agriculture, Madras.	Ditto.
33	Bulletin No. 71 : 'Irrigation'	R. Cecil Wood, M.A., Principal, Agricultural College, Coimbatore.	Ditto.
34	Year Book of the Department of Agriculture, Madras, 1917.	Ditto ..	Ditto.
35	The Madras Agricultural Calendar for 1917-18. Price Anna 1.	Issued by the Department of Agriculture, Madras.	Ditto.
36	*The Agricultural and Co-operative Gazette* (Monthly) from February 1917 to July 1917. Price Annas 2 per copy.	Department of Agriculture, Central Provinces and Berar.	Shalom Press, Nagpur.
37	Report of the Mandalay Agricultural Station (including Natywagon Plot) for the year 1915-16.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
38	Report of the Padu Agricultural Station for the year 1915-16.	Ditto ..	Ditto.
39	Report of the Bugyi Experimental Plot for the year 1915-16.	Ditto .	Ditto.
40	Leaflet No. 1 of 1917 : 'Cultivation of Boro paddy (Assamese).'	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
41	*The Journal of the Madras Agricultural Students' Union* (Monthly). Annual subscription R. 1.	Madras Agricultural Students' Union, Coimbatore.	Literary Sun Press, Coimbatore.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
42	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphanage Press, Calcutta.
43	*The Journal of Dairying and Dairy-Farming in India* (Quarterly).	Published by the Indian Committee of the Dairy Education Association.	Messrs. Thacker, Spink and Co.'s Press, Calcutta.
44	*Poona Agricultural College Magazine* (Quarterly). Annual subscription. Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
	AGRICULTURAL CHEMISTRY.		
45	The Mandalay Milk Supply, Bulletin No. 15 of the Department of Agriculture, Burma.	F. J. Warth, B.SC., M.SC., Agricultural Chemist, Burma.	Government Printing, Burma, Rangoon.
	BOTANY.		
46	Annual Report of the Experimental Work of the Economic Botanist and his staff for 1915-16. Price As. 2, or 3*d*.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
	MYCOLOGY.		
47	The Dissemination of Parasitic Fungi and International Legislation. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. IX, No. 1. Price Re. 1-4, or 2*s*.	E. J. Butler, M.B., F.L.S., Imperial Mycologist.	Messrs. Thacker, Spink & Co., Calcutta.
	ENTOMOLOGY.		
48	Some Important Insect Pests of Cotton in the Punjab. Price As. 2.	Madan Mohan Lall, B. SC., Professor of Entomology, Agricultural College, Lyallpur.	Government Printing, Punjab, Lahore.
49	Hints on Silkworm rearing in the Punjab. Price As. 6, or 6*d*.	Ditto ...	Ditto.
50	Leaflet No. 3 of 1917: 'The Mango hopper pest and its control.'	T. V. Ramkrishna Ayyar, B.A., Acting Government Entomologist, Madras.	Government Press, Madras.
51	Leaflet No. 5 of 1917: 'A few home-made remedies against some common plant pests.'	Ditto ...	Ditto.
52	Bulletin No. 1 of 1916: Insects injurious to crops.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
53	Leaflet No. 1 of 1916: Rice hispa.*	Ditto ...	Ditto.

* Leaflets 1—9 have been issued both in English and Assamese.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Entomology—concld.		
54	Leaflet No. 2 of 1916: Rice bug.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
55	Leaflet No. 3 of 1916: Rice grasshopper.	Ditto ..	Ditto.
56	Leaflet No. 4 of 1916: Rice stem borers.	Ditto ...	Ditto.
57	Leaflet No. 5 of 1916: Brinjal borer.	Ditto ...	Ditto.
58	Leaflet No. 6 of 1916: Surface caterpillars.	Ditto ...	Ditto.
59	Leaflet No. 7 of 1916: Plant lice or aphis.	Ditto ...	Ditto.
60	Leaflet No. 8 of 1916: The White ants.	Ditto ...	Ditto.
61	Leaflet No. 9 of 1916: Insect pests of stored grains, seeds, &c.	Ditto ...	Ditto.
	AGRICULTURAL BACTERIOLOGY.		
62	Saltpetre: Its origin and extraction in India. Bulletin No. 68 of the Agricultural Research Institute, Pusa. Price As. 4, or 5*d*.	C. M. Hutchinson, B.A., Imperial Agricultural Bacteriologist.	Government Printing, India, Calcutta.
63	The Pebrine Disease of Silkworms in India. Bulletin No. 75 of the Agricultural Research Institute, Pusa. Price As. 3, or 4*d*.	Ditto ...	Ditto.
64	The Importance of Bacterial Action in Indigo Manufacture. Price As. 2, or 3*d*.	Ditto ...	Messrs. Thacker, Spink & Co., Calcutta.
	VETERINARY.		
65	*Kumri*: Combined Diffuse Sclerosis and Central Poliomyelitis of Horses. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. II, No. 8. Price R. 1, or 1*s*. 6*d*.	G. H. K. Macalister, M.A., M.D., D.P.H., Pathologist, Muktesar Laboratory.	Messrs. Thacker, Spink Co., Calcutta.
66	Bengali translation of 'Some diseases of cattle in India' by Major G. K. Walker. Price Anna 1.	S. C. Pal, Deputy Superintendent, Civil Veterinary Department, Bengal.	Bengal Secretariat Book Depôt, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*concld.*

No.	Title	Author	Where published
	Veterinary—concld.		
67	Annual Report of the Civil Veterinary Department for the year ending 31st March, 1917.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
68	Annual Report of the Camel Specialist, Punjab, for 1916-17. Annas 3, or 3*d*.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
69	Statistics compiled by the Government of India from the Reports of Provincial Veterinary Departments for the year 1915-16.	Issued by the Revenue and Agricultural Department of the Government of India.	G. M. Press, Simla.

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The Fourth Indian Science Congress was held at Bangalore in January, 1917. The Agricultural Section, over which I had the honour of presiding, was well attended and a number of interesting discussions took place. The present special issue of the *Agricultural Journal of India* contains a selection from the papers read. I am indebted to His Highness the Maharaja of Mysore, the Patron of the Congress, for kindly allowing his photo to be inserted as a frontispiece to this Number.

J. MACKENNA,

Agricultural Adviser to the Government of India.

Pusa,

March 16, 1917.

With acknowledgments to the Asiatic Society of Bengal, under whose auspices the Indian Science Congress was held, for their kindness in allowing us to publish the papers contained in this Number *in extenso*

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H. H. SHREE KRISHNARAJA WADIYAR, BAHADUR, G.C.S.I., MAHARAJA OF MYSORE.

PRESIDENTIAL ADDRESS.

BY

SIR ALFRED GIBBS BOURNE, D.Sc., F.R.S., K.C.I.E.,

Director of the Indian Institute of Science, Bangalore.

YOUR HIGHNESS,—My first duty is the very pleasant one of saying on behalf of the members of this Congress how much we value the honour Your Highness has done us in consenting to be our Patron and in coming here to preside at our opening meeting. Many of our members have come from distant parts of India and are paying their first visit to the State of Mysore; the interest of this visit is greatly enhanced by the pleasure of seeing Your Highness in person.

LADIES AND GENTLEMEN,—Before going further may I say how greatly I appreciate the honour of my new position as President of this Congress, a most unexpected honour as it is now fifteen years since I was caught up by the great wheels of administration and had during that time very little leisure or energy to devote to scientific work. This is one reason among others why I cannot follow in the footsteps of my distinguished predecessor and offer you, as he did, an intellectual treat.

I had at first hoped it would be possible for me to attempt some review of the history of science in India; and though I have been compelled to give up that idea as impracticable I should like to express my gratitude to Mr. K. V. Rangaswami Aiyengar of Trivandrum for the notes which he kindly compiled for me on the science handed down to us in Sanskrit literature. I make one quotation from these notes now; its bearing on my own remarks will be evident later. After pointing out that no scientific treatises in Sanskrit have come down which deal with the subject-matter of

any of the physical sciences in the direct modern manner, he says:—"Even in such cases as those of Indian astronomy and mathematics we find the purely scientific aim subordinated to the practical and the subjects treated of as incidental to the consideration of practical arts like mensuration or judicial astrology." I am not quite clear as to what judicial astrology is but we shall doubtless agree that it is not pure science.

I was particularly anxious that the Congress should meet in Bangalore in order to give its members the opportunity of becoming acquainted with the Indian Institute of Science, that they might see for themselves what has been so far the outcome of Mr. J. N. Tata's unique beneficent intention and what immense possibilities there are for the future if others would follow his excellent example.

Unfortunately the Institute itself is not a suitable place for the holding of our meetings owing to the lack of sufficient accommodation for visitors on the spot and the difficulties of transit to and fro. It is, however, an ill wind that blows no one any good, and as things are, we have the pleasure of accepting the hospitality ot His Highness' Government and of seeing at leisure the very excellent arrangements made in this so well-termed "go-ahead State" for the teaching and practice of science.

This is the fourth meeting of this Congress, and I think you will all join me in congratulating those who have worked so hard to bring such a Congress into being. Although Dr. Simonsen of Madras and Mr. MacMahon of Lucknow are perhaps responsible for its conception the Congress has hitherto found a complaisant foster-father in the old established Asiatic Society of Bengal and it may become permanently established as a peripatetic form of activity of that Society. That Society began life under the auspices of Sir William Jones and he wisely urged at its inaugural meeting that there should be no rules, and for a long time there were no rules and the Society flourished without them. There is, however, little doubt that he made what were virtually rules, although not so called, as occasion required. A founder may do this, but every society that persists beyond the time of its founder finds the need foı some

rules, however few and simple. This Congress has managed fairly well up to now without any, but one of the matters which will be brought before you at the present meeting will be the desirability of some simple constitution. We are indeed to have a discussion with regard to its future and I venture in the first place to offer a few comments and suggestions bearing upon the Congress.

The body to which the Congress most nearly corresponds is the British Association for the Advancement of Science. Such an organization found its place in the Salomon's House of Bacon's fable wherein they had "Circuites or Visits of Divers Principall Citties of the Kingdome; wher, as it commeth to passe, wee doe publish such New Profitable Inventions, as wee thinke good."

Like the British Association we may, I think, safely say that we contemplate no interference with the ground occupied by other institutions.

The objects of the British Association were at the outset declared to be:—

> "To give a stronger impulse and a more systematic direction to scientific enquiry;
> to promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers; and
> to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress."

These have remained its avowed objects for 85 years.

To speak of the last of these first, it has not the force now which it had in the early part of last century. There may still be comparatively few "whose favoured steps the lamp of science through the jealous maze of nature guides," but there is no comparison between the amount of general attention the objects of science now receive and the state of things in 1831. So far as a general appreciation of science, its aims and methods, was concerned those days were not so very very far removed from the time when "chymistes were distillers of waters" or people who "turned"—

or were supposed to turn—" everything into siluer " or perhaps in the East from the time when " the most eager search was the transmutation of metals and the elixir of immortal health." Indeed within the year just closed a gentleman came to the Institute of Science to show us how to obtain gold from egg-shells, and not long ago I received a postal order of no small amount with a request that the value might be remitted in boxes of our best brain pills.

Science of some sort is now being very widely taught at all stages of education, and so far from its progress being impeded, as used to be the case, by disadvantages of a public kind, most Governments are more or less alive to the importance of devoting public funds in furtherance of scientific work, and almost every Honours List now contains the names of men distinguished in science.

In this country the various Governments have made a very fair beginning in the matter of funds.

It is impossible, and would be of little value for our purposes, to estimate the amount devoted to scientific teaching in schools and colleges by the various Education Departments. I have, however, endeavoured with the kind assistance of the Hon'ble Mr. Davidson and the Financial Department of the Government of Madras to form some idea of the amount being spent upon original research and other higher scientific work throughout the country.

On the nature and essence of " research " I propose to offer a few observations later on, but it is not without interest to note at this point the connections in which the word occurs in the various budget estimates. The Government of India support a Forest *Research* Institute and College at Dehra Dun and devote about four lakhs a year to it ; they contribute five lakhs a year to the Indian *Research* Fund, about five and a half lakhs to the Agricultural *Research* Institute at Pusa, and a lakh to the Central *Research* Institute at Kasauli.

Some of the Local Governments have entertained, or propose to entertain, what they call in the budget, forest *research* officers. The Agricultural College in the Madras Presidency has for part of its title that of *Research* Institute. The Government of Bengal give *research* scholarships. The Punjab Government enter a small

portion of their contribution to Government colleges as *research* grant. In Burma a small sum is devoted to what are called leprosy *researches*.

The budgets, however, provide for many other forms of scientific activity in connection with which the word research does not happen to have been used, such as further experimental work in connection with agriculture, bacteriological work as affecting men and animals, other investigations of a medical nature, and work relating to fisheries and other industries.

Further, various Governments support museums in some of which at any rate scientific work is carried on, and our Institute here at Bangalore receives an annual grant of Rs. 87,500 from the Government of India who have promised, should any private individual be willing to subscribe, to provide a like amount so long as their total grant does not exceed Rs. 1,50,000.

Lastly, there are the various Imperial Surveys; in some of these the expenditure must of course be mainly debited to administrative work but in the majority of them the funds do something towards the progress of science.

In all these ways and without taking the Surveys into account the annual expenditure from public funds on scientific work in British India is somewhere in the neighbourhood of Rs. 70-80 lakhs, that is to say £500,000, and to this must of course be added large capital sums invested in buildings. I have the exact figures under each head, but the difficulty comes when one endeavours to pick out the expenditure resulting in additions to scientific knowledge and I have given the Government the benefit of the doubt in the majority of the doubtful cases.

This expenditure is supplemented to some extent by the more progressive of the Native States including, I need hardly say, the State in which we have the pleasure to be at present.

Lastly, private sources have contributed, but to a lamentably small extent. In this latter respect there have been a few striking exceptions and perhaps the foremost of these was the projected gift of the late Mr. Tata to the carrying out of which by his sons our Institute owes its existence.

So far as Government contributions are concerned I must leave it to others interested to make more exact calculations particularly with a view to deciding what share of this expenditure is intended to make for progress in science and to institute comparisons with similar efforts in other countries. I cannot arrive at any total for expenditure in Great Britain on corresponding objects, but I note that at the opening of the National Physical Laboratory in England in 1902 His Majesty the King, then Prince of Wales, expressed the belief that it was "almost the first instance of the State taking part in scientific research," and that the capital grant towards that laboratory was £13,000 (under two lakhs of Rupees) and that the annual allowance towards its maintenance was £4,000 (0·6 lakh in our budget terminology), while the only other sum mentioned by the recently appointed Advisory Council as a State contribution of any magnitude in the pre-war period of the present century, is an annual subsidy of £20,000 (since increased to £30,000) to the Imperial College of Science and Technology at South Kensington. I would ask you to compare these figures so far as they go, on the one hand with those I have just given for some individual institutions in India and on the other with the amount that must have been contributed from private sources in England.

I do not ask you to make any odious comparison with what has been spent by any State in Central Europe but would remind you of a private benefaction in another continent of about 22 million dollars, yielding an *annual* income of what amounts to over Rs. 30 lakhs in our currency.

I do not intend to dwell further on finance, nor need I linger over the other ways in which science has obtained recognition in recent years, but it is clear that much has been done not only to remove disadvantages of a public kind but actually to further the progress of science since the Association we have taken as a model was founded. This Congress may now do its share.

With regard to the first object of the British Association, *viz*, to give a stronger impulse and a more systematic direction to scientific enquiry, I would ask this Congress to consider how it can secure this stronger impulse and particularly a more systematic direction.

It seems doubtful whether much will be done in this respect if the programme continues to be limited to an address from the President, a few public lectures and, for the rest, meetings in small Sections for the reading of papers some of which I gather from past proceedings have been mere preliminary notes, while others, although valuable contributions to science, are of immediate interest to very few.

I am not instituting any comparison, invidious or otherwise, in this respect with the British Association but should like to point out that from its foundation onwards some of the most important work of that body is to be found in the "Reports on the State of Science." The Board of Scientific Advice in India has, it is true, for several years published an Annual Report and in some subjects this gives a very fair idea of the progress during the year but in others it is little more than an extract from some administration report and there seems to be no attempt at co-ordination nor any endeavour to formulate desiderata.

In these days of increasing specialization great effort ought to be made by those working at one subject to get some notion of the progress in others. To make one or two suggestions there might be some greater effort at combined meetings to deal with subjects in which all or most scientific men must take some interest, there might be permanent committees dealing with specific problems and the President of each Section, if you must have Sections, might endeavour to review recent work in his subject. This latter is indeed frequently done, but as these addresses are usually all delivered at the same hour they are for the most part listened to only by those who best know beforehand what that work has been.

The other object which the British Association sets before itself, *viz.*, to promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers, has always seemed to me, even taken alone, to justify the annual meeting, but here again the object would be more fully attained were something arranged other than that the agriculturalists should shut themselves up in one room, the chemists in another, while the devotees of natural science segregate

themselves in various ways and pay very scant attention even to one another. I can quite sympathize with the botanist failing to appreciate the beauty of a paper " On a Cubic Surface referred to a Pentad of Co-tangential Points " or the chemist being somewhat bored by a disquisition " On the Aberrant Form of the Sacrum connected with Naegele's Obliquely Contracted Pelvis," but is an Association or Congress with its rare opportunity of meeting a number of fellow-workers in science, albeit in other branches, a suitable occasion for such papers ?

Should not some attempt be made throughout the meeting to deal with subjects intelligible to all students of science alike ? There must be something in the complaint recently made by Prof. Armstrong that a science nowadays may develop a special language threatening to estrange the users altogether from common knowledge and sympathy and some of us fully appreciate the demand he quotes " that chemists should talk common sense in the vulgar tongue."

Should not such meetings as this be almost entirely devoted to the bringing together all the time of all the scientists present ?

To quote the hitherto unborn words of the memorandum to be presented by my Council to the Industries Commission " the isolation hitherto experienced by many scientific workers in India has been one of the chief reasons of the comparatively disappointing results."

Now if you will bear with me a little longer I propose to revert to the question of research.

I have already drawn your attention to the frequent use of the term research in the Government budgets of the day. Look only a few years back and you will hardly find it in these documents. I have not been at any pains to measure the increase of frequency in the general use of the word, but it is certain that it is now being continually brought before a public few of whom concerned themselves much with the matter in the very recent past.

Research is now alluded to as a perfectly simple operation, one even hears of men being " taught to research " ; newspapers speak of it in the lightest manner ; whereas in even my student days

it was spoken of with almost bated breath as indicating something to which only the best of us could look forward, something which few of us were ever likely to carry on with any hope of success. How well I remember my own first piece of original work and the months I spent in trying to ascertain the structure of an organ little more than just visible to the naked eye and the excitement of trying to unravel its extreme complexity. My impression is that the term was at that time used almost entirely in connection with pure science, but even in this respect it is now quite a common thing for a candidate for a higher degree in science to be expected to present a thesis based upon some original research, and there is a professor in this country who, so I have been told, expects and helps each of his students to "turn out a research," to use a now common expression, every month. This may or may not be true. If true, it bespeaks considerable energy; how far it makes for progress authorities in the subject alone can say--at any rate it may serve as an example of how things have changed.

Then again instead of there being one or two isolated cases of institutions professedly devoted to research, such institutions are now quite common. Some of these I have already alluded to including that which is perhaps the most ambitious of all—The Carnegie Institution of Washington, founded by Andrew Carnegie "to encourage in the broadest and most liberal manner investigation, research and discovery, and the application of knowledge to the improvement of mankind."

Perhaps the most striking and modern example of the use of the term has been the name given to the recently appointed Committee of the Privy Council—a Committee for Scientific and Industrial Research; this has still more recently become a separate Department of State and bids fair to influence profoundly the position of research. I have based some of my remarks upon the instructive report lately issued by the Advisory Council of that Committee.

As this is a Science Congress there are probably few present to whom this will not be the merest commonplace, but there seem to be many people in this and in other countries who have not yet fully realized that the word research is now in use in ways that

differ greatly from one another. Almost all investigation is now spoken of as research. This is doubtless verbally correct, but the motive directing the investigation and the spirit in which it is carried out vary, and it seems desirable to emphasize the variations.

The Oxford Dictionary defines a researcher as "one who devotes himself to scientific or literary research (especially as contrasted with one whose time is chiefly occupied in teaching or remunerative work)." The word research is now, however, very widely used in connection with remunerative work, that is to say, remunerative in a pecuniary sense.

The Advisory Council to which I have just referred quote the managing director of a manufacturing firm who stated that he had no interest in research which did not produce results within a year: it is evident that he meant results favourably affecting his own pocket.

Dr. Mees, the Director of the Research Laboratories of the Eastman Kodak Company, no doubt takes a wider view. His interesting paper has been published in *Nature* but I take the following from the Advisory Council's report :—

"In this paper Dr. Mees points out that three grades of laboratory are needed by every manufacturer who wishes to get the best results from the application of science to his business. First he needs the ordinary routine or works laboratory for controlling the quality of raw materials, finished products, and processes. Next he should have what Dr. Mees calls an industrial laboratory or, as it might perhaps be described, an efficiency laboratory where improvements in products and in processes tending to lessen cost of production and to introduce new products on the market are worked out. Valuable as this type of work is, it does not go to the root of things; the results it can give are strictly limited.

"Fundamental developments in the whole subject in which a firm is interested require something very different from the usual works laboratory. In every case where the effect of research work has been very marked, that work has been directed not towards the superficial processes of industry but towards the fundamental and

underlying theory of the subject. The function of the third type of laboratory—the true research laboratory—is to formulate this underlying theory.

"This kind of research work involves, Dr. Mees tells us, a laboratory very different from the usual works laboratory and also investigations of a different type from those employed in a purely industrial laboratory. It means a large, elaborately equipped, and heavily staffed laboratory engaged largely on work which for many years will be unremunerative and which, for a considerable time after its foundation, will obtain no results at all which can be applied by the manufacturer. The shortest period in which any considerable results can be expected is five years, while results so considerable as to affect the whole industry cannot be looked for in less than ten years' consecutive work."

You will observe that even Dr. Mees' highest form of research, that carried on in the true research laboratory as he calls it, is to be conducted with a view to remunerative results although these may be deferred for 5 or even 10 years!

I would ask you to contrast this attitude with that indicated by Sir Ray Lankester in a lecture delivered at the meeting of the British Association in Sheffield. Lankester pointed out how different from "the eager practical spirit of the inventor who gains large pecuniary rewards" was "the devoted searching spirit of science which heedless of pecuniary rewards ever faces nature with a single purpose to ascertain the causes of things." "Invention," he said, "follows the footsteps of science at a distance. She is utterly devoid of that thriftless yearning after knowledge, that passionate desire to know the truth, which causes the unceasing advance of her guide and benefactress."

It is probably impossible to find a classification of research work devoid of considerable overlapping, and in many cases the motives are undoubtedly mixed, but it seems possible to recognize three classes:—That carried on with the single purpose of ascertaining the truth in regard to the causes of things, that which has for its immediate object a specific utilitarian purpose but still without any expectation whatever of a pecuniarily remunerative result, and

research with the avowed object of making money out of it sooner or later.

The first and second classes would come under the head of scientific research in the sense in which the term is used by the Privy Council, while the third class is industrial research ; but what I want to emphasize is the fact that the first class alone is research in pure science while the second and third classes are both research in applied science, that is science put to practical use, practical as distinguished from abstract or theoretical.

Huxley said that what people call applied science is nothing but the application of pure science to particular problems. The Advisory Council say that this no doubt is so ; there are not two different kinds of science, at the same time they realize that they have to deal with the practical business world in whose eyes a real distinction seems to exist between pure science and applied science. There are, however, men in the business world who see more clearly. An American manufacturer pointed out only the other day that "there are no sharp lines to separate pure from applied, scientific from practical, useful from useless. If one attempts to divide past research in such a manner he finds that time entirely rubs out the lines of demarcation."

It is interesting to note in passing that the word "applied" is being increasingly used in connection with specific branches of science. I have been unable to trace the history of such usage. The term applied mathematics must have considerable antiquity. There have for many years been chairs of applied mechanics, applied physics and technical chemistry, but I have failed to find any early use of the term applied chemistry. Some branches of science have an applied side with a special title, such as economic botany, others are in their very nature wholly applied, such as agriculture and medicine.

But whatever terms have been used the application of scientific knowledge for the good of mankind is as old as that knowledge itself, and one may safely say that the majority of those who have attempted this application have not been swayed by any pecuniary motive. The scientific agriculturist is not in most cases the person

into whose pockets comes the money secured by the use of better methods. Medical science in all its branches is, as I have just said, applied science and although the doctor may earn his living by means of fees, medical research is not undertaken from pecuniary motives. It has been for the most part the application to a particular problem of the scientific knowledge of the day, and there has of course been no such application with a more noble purpose. Still it is not pure science, and there have often been medical men who have left further application to others while they have reverted to purely scientific problems.

Sir Francis Bacon in the fable already quoted seems to have had in mind pure science on the one hand and applied science on the other : —

" Wee have Three that try New Experiments such as themselves thinke good. These wee call Pioners or Miners.

* * * * * *

" Wee have Three that bend themselves, Looking into the Experiments of their Fellowes, and cast about how to draw out of them Things of Use, and Practise for Man's life and Knowledge.

* * * * * *

" These wee call Dowry-men or Benefactours."

Observe who are the " Benefactours " and in the use of this term we all doubtless most cordially agree ; personally I would not have it supposed for one moment that I am belittling research even if undertaken from pecuniary motives or would say one word to detract from its importance. All I maintain is that pure science must remain upon a pedestal and no utilitarian work can replace it.

Dr. Mees may talk of going to the root of things and of the fundamental and underlying theory of a subject in connection with his industrial research, but all this is for the most part mere superstructure based on pure scientific research.

What utilitarian research would have discovered the fundamental facts in regard to electricity or have led to the framing of the atomic theory ? Who can say how many profound truths await discovery because some utilitarian who happened upon a glimmering

of them did not think it worth while to pause and investigate the apparently irrelevant? In like case your "Pioner or Miner" eager to ascertain the causes of all things would have asked no better lot than to follow up the faintly marked trail wheresoever it might lead, perchance in the end to the elucidation of some great truth susceptible of an application which might completely revolutionize the very subject upon which the utilitarian had been at work.

How much research has been undertaken by the student of pure science which he would have frankly admitted to be apparently useless? How much patient work and loving care have been bestowed upon investigations seemingly impossible of application to any of the specific problems of the day? Upon research of this kind no utilitarian would have been at all likely to embark, yet sooner or later such research has either proved capable of direct application, or (this has more often been the case) has unexpectedly formed a corner-stone, or occupied a more humble but still useful position, in building up some far-reaching generalization capable of being seized upon at once by the worker at applied science, thus in turn perhaps stimulating further scientific research.

It has been said that "even the brilliant experiments of Davy did not suffice to give any very great impetus towards further work at the subject until Ronalds constructed an electric telegraph, and in this and other ways pure electrical science received enormous impulses by the commercial applications of electricity." Thus according to Sir Frederick Bramwell "the applications of science and discoveries in pure science have acted and reacted the one upon the other." No one can deny the existence of such action and reaction, but nevertheless it remains true that each one of the modern practical applications of science, from wireless telegraphy to anti-toxins, "had its foundations in purely scientific work, and was not the result of deliberate intention to make something of service to humanity." You will, I think, find evidence of this in the work from which I quote, Professor Gregory's "Discovery; or the Spirit and Service of Science."

The immediate recognition of the value of applied work implied in the term "Dowry-men or Benefactours" does not of course

trouble those with the "thriftless yearning," they have faith that sooner or later their work must fit in towards some useful purpose. We have heard of mathematicians who drink the toast "Here's to pure mathematics and may they never be of any use to anybody," but even they know that mathematics rule and govern a great variety of subjects. Most students of pure science believe, to use weightier words than mine, that "you cannot get the science you desire for utilitarian ends by going straight for it. You must treat science with profound honour and respect and let her go on her own way. Then she will give you rich fruit, if you try to cripple and force and direct her to your own immediate ends she dries up and becomes a mere hag." Had there not been in the past men imbued with this spirit there would have been no scientific knowledge to apply to any particular class of problem, and any widely successful effort to wean the earnest student of pure science from his single purpose for any utilitarian end and, above all, by means of pecuniary reward, must spell disaster for the distant future, and may hamper progress long ere that, but I cannot believe that a time will ever now come when there will not be many whose passionate desire to know the truth will rule them to the end.

This being so, it behoves even us, devotees of pure science, to do all we can to train and assist the race of "Dowry-men and Benefactours" and this is why I so strongly advocate the giving over of the Institute of Science to work of an applied character. We shall rejoice over any one in whom is born the passionate desire, but we must face the fact that men are wanted, and that in very large numbers, who will help the manufacturer, in the words of the Advisory Council, to overcome the difficulties that cross his path from day to day. The training of such men is indeed of the utmost importance if we are to emerge from the cloud that at present hangs over so many of our industries. A time is coming, we all devoutly hope that it may come soon, when things may return to their normal courses, but this cannot be until many years after this war is over. Then men of science all the world over can continue to pile up reserves in the way of knowledge and we know that the *best* will remain "Pioners and Miners." Now our greater need by far is for

the "Dowry-men or Benefactours"; there are ample balances upon which to draw, balances inherited from the "Pioners or Miners" who have gone before.

I have spoken of the cloud that hangs over industries, but one cannot forget that even this is as nothing when the whole sky is overcast, when young, middle-aged and old alike, men of science as well as others, are sacrificing everything, forsaking what have hitherto been their ideals, giving their very lives, for the sake of what they hold to be a righteous cause.

We too are doing the duty allotted to us and, precluded from more active help, must take what comfort we can from Milton's words, "They also serve who only stand and wait."

My chief duty as your President is now over.

I fear I may have very partially succeeded in putting before you my own somewhat conflicting thoughts, but it seems to me that a new danger of misconception in regard to science may loom large in the near future—pure science may be almost submerged for a time by a wave of utilitarianism, and it will require concerted and sustained effort to make people see things in their proper proportions. The motive of the utilitarian is so obviously unimpeachable; the student of pure science may be, in the words of the Preacher, casting his bread upon the waters whence it may return only after many days. On the one hand is the crying need for active help, on the other is the conviction as to what is the ideal. I do no more than ask you as citizens of the Empire and as students of science to reflect upon these matters. Each must follow the dictates of his own conscience.

"To thine own self be true;
Thou canst not then be false to any man."

THE ECONOMIC SIGNIFICANCE OF THE ROOT-DEVELOPMENT OF AGRICULTURAL CROPS.

BY

ALBERT HOWARD, C.I.E., M.A.,

Imperial Economic Botanist, Pusa ;

AND

GABRIELLE L C. HOWARD, M.A,

Second Imperial Economic Botanist, Pusa.

THE detailed study of the root-systems of the various agricultural crops has been greatly neglected in the past. Hitherto, far too much attention has been devoted to the above-ground portion of the plant and it has almost been forgotten that a very large part of any crop consists of the root-system which is ordinarily out of sight. This omission to study the relation between the soil and the distribution of the roots is a common feature of the variety trials which nowadays form so large a part of experiment station work. Various types of crop are grown side by side and the harvest weighed. The highest average yielder is pronounced the best and the remainder fall out of favour and suffer neglect. There is seldom any attempt to probe the matter further and to determine why a certain variety suits some particular set of conditions and why others do not. In most cases, the investigator is content with merely arranging his varieties in order of merit according to the yield of some economic product like seed or fibre. The best of the varieties, however, are erratic in their behaviour and the variation in yield from year to year is considerable. It is hoped to get over this difficulty by repeating the trials and by averaging the yields. The results so obtained are not altogether satisfactory. A study of the figures obtained in variety trials generally leaves behind an

uneasy feeling that something more is required than the annual comparison of the yield.

The object of this paper is to show that a comparative study of the root-systems of a set of varieties throws a considerable amount of light on the relations which exist between the most suitable type of crop and the soil in which it grows. The results of variety trials often become considerably clearer from a study of the roots of the various varieties tried.

What are the essential things required for root-development? Besides water and dissolved minerals, the roots must have abundant room in the soil for rapid growth and this space must be adequately ventilated. The soil of a field has been described by King as a pasture on the internal surfaces of which abundant plant food materials grow. These raw materials are produced by the mutual interaction of the soil organisms, the organic matter in the soil, the moisture, air and the roots of crops. As a result of this intense activity, the more insoluble forms of potash, lime, magnesia and phosphoric acid are brought into solution. At the same time, the nitrogen and other plant food elements of the organic matter are transformed into simple substances available for the use of crops. The roots, however, cannot make full use of all these raw materials unless there is abundant room for development and unless the air in the pore spaces can be frequently renewed from the great reservoir, the atmosphere. The roots are alive, the protoplasm of the active cells respires. This involves a continuous oxygen supply and the simultaneous production of carbon dioxide which, if allowed to accumulate in the pore spaces to too great an extent, would check the activities of the soil organisms and of the roots themselves. For proper root-development, therefore, the soil must be aerated.

Now in the alluvium of the plains of India one of the most difficult things is to manage the soil so that its aeration is not interfered with by rain or by irrigation water. The crumb structure of fine alluvial soils which is so easy to produce, is also readily lost under monsoon and irrigation conditions. In consequence, the soil and the roots of the crops cannot obtain sufficient oxygen and in many cases carbon dioxide accumulates. The crops suffer from

lack of aeration in the soil and oxygen becomes a limiting factor. This is the explanation we have suggested for a whole series of phenomena relating to crops on the Indo-Gangetic alluvium. All the facts so far obtained fit into the aeration theory and we have come to regard the surface layer of the alluvium as a vast oxygen filter separating the atmosphere from the sub-soil water which, analysis shows, is particularly poor in dissolved oxygen. All soil-aerating agencies like surface and sub-soil drainage at once increase production provided the supply of organic matter in the soil is adequate. Now if this is true and if the Bihar alluvium does act as an oxygen filter we should expect to find that all the varieties which really thrive during the monsoon phase in this tract are surface-rooted and that very deep-rooting kinds would not do well. To some extent, a similar rule ought to hold in the cold weather (*rabi*) crops but not to quite the same extent, as in these crops the rainfall between sowing time and harvest is small and during this period soil aeration is at its best We have from time to time investigated this point and have dealt with some of the results obtained in the present paper.

I. Linseed.

The linseed crop of India is mainly concentrated in two areas—(1) on the soils of the Peninsula in Central India and the adjacent tracts and (2) on the alluvium north of the Ganges in Bihar and in the eastern Districts of the United Provinces. Outside these regions, the crop is not very important except perhaps in the Kashmir valley. An examination of the plant shows that the types of linseed from the Peninsula fall into one well-defined class and are quite distinct from the varieties found on the Gangetic alluvium. The linseeds of Peninsular India form large bold seeds, are erect in habit and are, generally speaking, early types. The linseeds of the alluvium, on the other hand, have small seeds and are later in coming to maturity. Associated with these above-ground characters are differences of equal magnitude in the root-systems. The linseeds of the Peninsula are deep-rooted, the branching of the tap-root takes place mainly at a point about a foot below the ground level. Although the rooting is deep, the amount

of the root-development is not very great. The linseeds of the alluvium are shallow-rooted. The main tap-root sends out strong lateral branches parallel with the surface and practically the whole extensive root-system is concentrated within the first ten inches of soil. The two types of rooting are shown in Fig. 1. It would appear that soil aeration is the dominant factor in the type of linseed to be grown. On the Peninsula the cracking of the soil enables the sub-soil to be aerated and thus permits the crop to form a deep root-system and to abstract moisture from the lower layers. On the alluvium, the roots are compelled to run near the surface so as to get a sufficient air supply. If we transfer the Peninsular types to the alluvium, they root just as if they were on the black soils and the main root always begins to branch at a point well below the surface. With the formation of this deep root-system, signs of wilt make their appearance, the lower leaves die off and the whole plant begins to turn yellow. Only by deep cultivation and thorough aeration can these types form seed which however in size and in appearance is far below the standard of the original stock. Side by side, the types of the alluvium form excellent seed.



Fig. 1. Linseed from Central India (left) and the Indo-Gangetic Alluvium (right).

II. Gram.

The distribution of the gram crop in India depends chiefly on two factors—soil temperature and soil aeration. Gram is an

important cold weather crop to the north of a line joining Bombay and Patna, and is not found to any very great extent on the warmer soils to the southward. In the gram tract itself, the density is greatest where the natural aeration of the soil is above the average. Thus for example on the alluvium, the crop is mainly concentrated in the Province of Agra and in the *barani* tracts of the Eastern Punjab where the natural aeration of the soil is good. On the Gangetic alluvium, gram decreases towards the Bay of Bengal and is less important the finer, denser and moister the alluvium becomes. The crop is only irrigated to advantage in areas like the Agra Province and the Bombay Deccan where surface-flooding does not interfere with the natural aeration of the land. On stiff soils like those of the Chenab Colony and Sind, gram does not thrive under surface-flooding. On the soils of the Peninsula which are particularly well aerated, gram is important wherever the soil is cool enough for the crop. The general facts of distribution are shown in Table I.

TABLE I.

Area and average yield of gram in 1911-12.

Province	Area (in acres)	Yield (irrigated) in lb. per acre	Yield (unirrigated) in lb. per acre
Assam	905	....	....
Bengal	176,700	....	881
Bihar and Orissa	992,100	....	881
Oudh	1,697,097	950	800
Agra	5,175,443	625	534
Punjab	4,099,894		
N.-W. Frontier Province	174,119	730	449
Sind	76,439	476	....
Bombay	422,274	1,200	420
Central Provinces	993,113	....	532
Berar	117,221	....	....
Madras	134,900	....	....
Upper Burma	38,905	....	414
Lower Burma	1,377	....	....
Ajmer-Merwara	26,176	....	....
Coorg	1,540	....	....
Pargana Manpur (C. I.)	678	....	....
Total—British India	14,128,881	Average yield 688 lb. per acre.	
Total—Native States	4,039,929		
GRAND TOTAL	18,168,810		

That the distribution of the crop in the gram area itself depends on the aeration of the soil is supported by the results obtained at Pusa. On high, light land the crop does well. On stiff, clayey, badly aerated plots the yields are poor. The results are summed up in Table II.

TABLE II.

Yield per acre of grâm varieties at Pusa in 1912 *and* 1913.

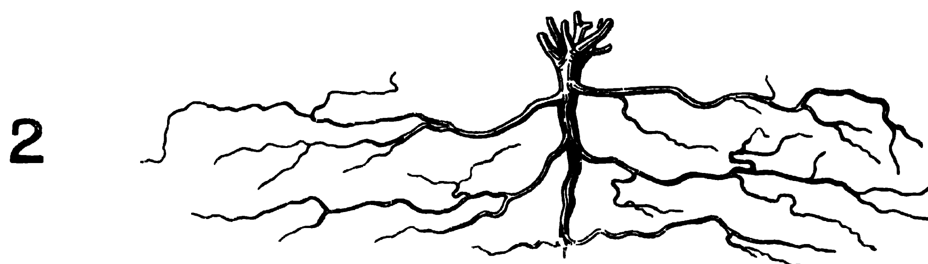
Variety		1912 (light land)		1913 (heavy land)		
		Mds	Srs	Mds	Srs.	
Local	..	14	27	4	0	West side of plot in 1913, land very heavy.
Type 14	..	23	35	3	24	
Type 17	..	30	31	3	22	
Type 9	..	32	16	15	8	
Type 16	..	13	28	10	0	
Type 18	..	34	27	9	28	East side of plot in 1913, land moderately heavy.

The poor results of 1913 were entirely due to the fact that gram does not root well on heavy land. On the heaviest land at Pusa, the root-system is diseased and superficial; on light, well-aerated land it is deep and on soils between these the depth of rooting is intermediate. These results are shown in Plate I.

If further we compare the yield of the same varieties on the same class of soil in wet and dry seasons, further support of the aeration theory is obtained. If the yield is limited by the aeration of the soil, it would be expected that under such conditions in a wet year late, deep-rooting varieties would not do well and that the best results would be obtained from early flowering, shallow-rooted types.

The results are given in Table III, and it will be seen that the yield in a wet year is inversely proportional to the depth of the root-system.





3

SOIL-MOISTURE AND ROOT-DEVELOPMENT

TABLE III.

The relation between yield and root-development in a wet season.

Variety	Date of flowering	Average length of tap-root bearing laterals	Area in acres	Yield per acre, 1915		Yield per acre, 1914	
				Mds.	Srs.	Mds.	Srs.
Type 9	Feb. 18th	16 cm.	1.5	12	22	32	16
Type 17	Feb. 4th	13 cm.	1.0	18	9	30	31
Type 18	Jan. 18th	8 cm.	1.0	23	27	34	27

III. WHEAT.

Very little work has been done in India in tracing the connection between the root-systems of wheat varieties and their suitability for certain types of soil. The matter, however, is being taken up at Pusa and it is possible to refer to some of the preliminary results.

Some very interesting details have been obtained on this point in connection with the distribution of Pusa 12. Pusa 12 is a deep-rooting, high-yielding variety. It was isolated from a mixture in the Botanical section at Pusa where it was found that this type gave excellent results on the lighter wheat soils of the experiment station but was apt to be disappointing on the heavier lands. When tried in the United Provinces, however, it quickly came into favour. Excellent crops were obtained; the size of the ears and the yield were greater than anything that had been obtained at Pusa even with the best cultivation. The soils of the alluvium of the United Provinces are more open than those of Bihar and this deep-rooting wheat immediately responds. On the other hand, the wheat which suits Bihar best is Pusa 6, a shallow-rooted variety which does not do well in the drier wheat-growing areas of the Indo-Gangetic plain. Here shallow-rooting is a distinct disadvantage.

IV. HIBISCUS SABDARIFFA AND H. CANNABINUS.

These two species of fibre plants, which are usually sown at the break of the rains in Northern India, differ greatly in two respects—in the amount of branching and in their tolerance of moist soil conditions. The varieties of *H. Sabdariffa* are much

branched and show little signs of wilt. The types of *H. cannabinus*, on the other hand, are tall, erect plants which, when grown in the ordinary way for fibre, branch little and are particularly prone to wilt. These distinctions between the two species are correlated with marked differences in the root-systems. The main tap-root of *H. Sabdariffa* is comparatively short but there is a great development of lateral roots which run parallel and quite close to the surface. The root-system is extensive, but it is concentrated near the surface of the ground and in very wet seasons leaves the soil and grows out into the air. The development of the aerial roots all over the surface of the ground was very marked in the wet monsoon of 1916. In *H. cannabinus*, the tap-root is deep and the development of the laterals is not concentrated near the surface. The root-system in this species is much deeper than in the case of *H. Sabdariffa*. The general differences in the root-system of the two species are shown in Fig. 2. The general connection

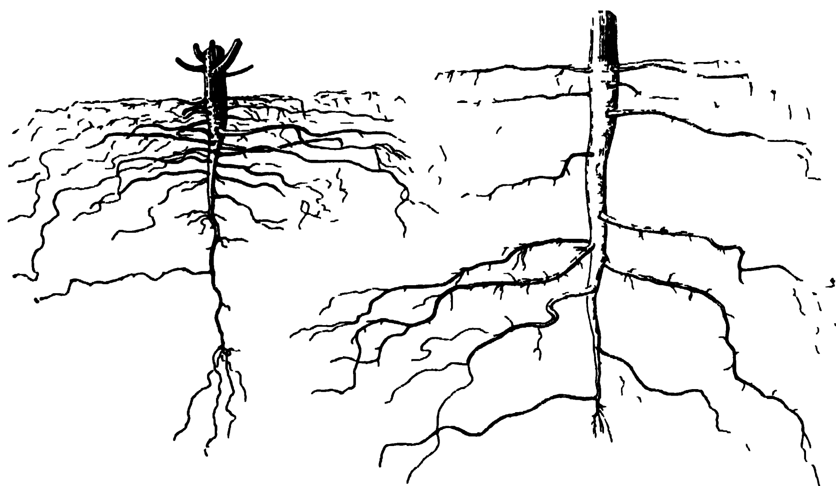


Fig. 2. The root-system of *Hibiscus Sabdariffa* (left) and *H. cannabinus* (right).

between the depth of the root-system and the liability of the two species to wilt will be evident. In the case of *H. Sabdariffa*, the aeration of the roots is easy and the crop thrives even in wet years. In the case of *H. cannabinus*, aeration is more difficult and the plants are very liable to wilt.

H. Sabdariffa. The root-systems of the varieties of *H. Sabdariffa* furnish an interesting illustration of what may be referred to as tolerance. Four varieties of this crop have been studied at Pusa and in all cases the root-systems are identical as regards distribution. Three of the varieties, however, thrive better than the fourth, a type of plant which was met with near Bhagalpur south of the Ganges. This Bhagalpur variety when grown at Pusa is not so robust as the others and often shows sickly foliage. Its roots are frequently discoloured in wet seasons and it does not appear to tolerate a constantly wet soil. This factor is inherited and in the offspring of crosses frequently leads to trouble in the study of the inheritance of characters in this species.

In the case of *H. cannabinus*, there are considerable differences in growth period among the various varieties. Some are early,

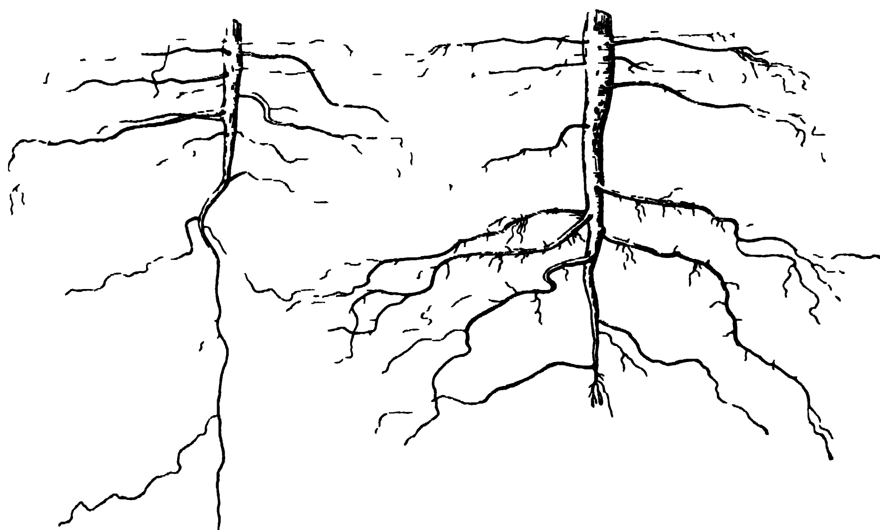


Fig. 3. Early (left) and late (right) types of root-systems in *H. cannabinus*.

others very late and intermediate types occur. The earlier types set seed well and do not suffer from wilt under Bihar conditions. The late sorts, on the other hand, set seed with difficulty and readily die of wilt. These differences in time of maturity and in liability to wilt become explicable when the root-systems are compared. In the early types, the roots branch near the surface and there are few laterals on the lower portion of the tap-root. (Fig. 3.)

In these cases, aeration is easy and there is no wilt. In the late types, a large portion of the laterals are found on the lower portion of the main root with the result that aeration becomes more difficult and wilt is much more frequent.

V. Java Indigo.

Up to the present, we have considered the root-systems of crops which are either grown in the monsoon or in the cold weather. Bihar agriculture, however, has to deal with a plant—Java indigo—which is grown all the year round including the hot months of April and May. Any successful type of plant must accommodate itself to a set of soil conditions ranging from extreme wetness in the monsoon to comparative dryness in the hot weather.

Java indigo as grown in Bihar is an exceedingly mixed crop and consists of a large range of types which, however, fall into two main classes as regards branching—(1) bushy types which branch to very varying degrees from the base, the branches coming off nearly at right angles to the main axis, and (2) tall vertical types whose branches arise at an acute angle from the stem. These two conditions may be shortly described as the bush type and the vertical type. Running through both these classes of branching are great differences in the rate of growth and in the time of flowering. Some of the types are early; others are exceedingly late. Some grow slowly; others much more rapidly. All grades of intermediates naturally occur.

Examination of the root-systems of these various types yields some very interesting information. In the first place, it should be mentioned that all types of Java indigo possess a deep-anchoring root which explains why this crop can so easily withstand the hot season in Bihar. The next point that emerges is the general correspondence between the modes of branching of the stem and of the root. In the bush types which branch at right angles to the axis, the lateral roots are also given off at right angles to the main tap-root. In the vertical types, the lateral roots arise at an angle

PLATE I



THE ROOT-RANGE IN EARLY-FLOWERING TYPES OF JAVA INDIGO.

very similar to that in the case of the branches. These general differences are shown in Figs. 4 and 5 and in Plate II.

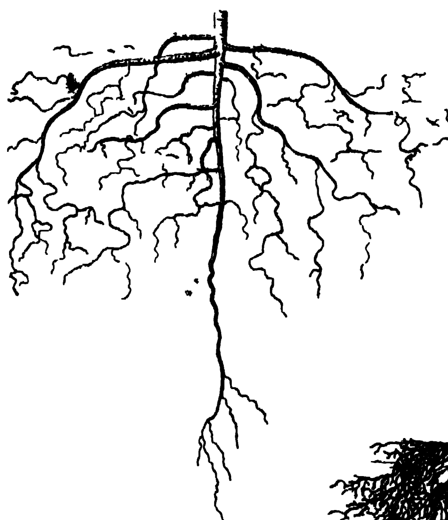


Fig 4. The root-range of an early bush type of Java indigo.

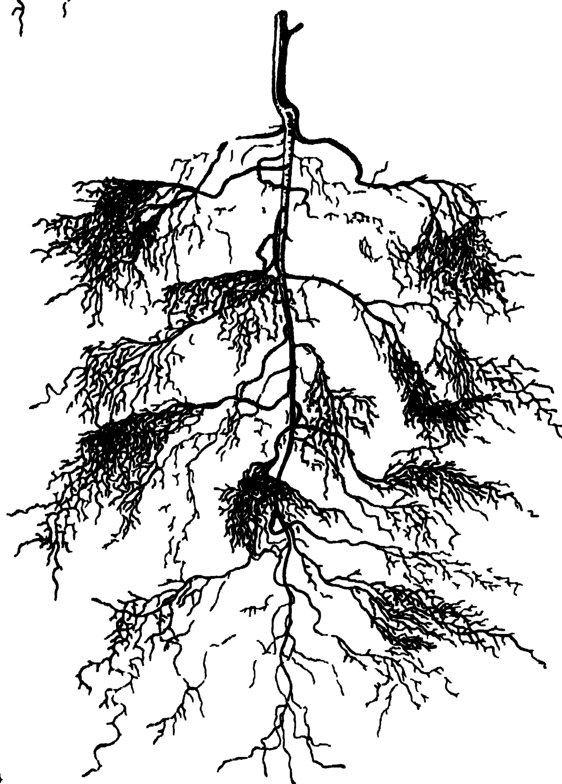


Fig 5 The root range of a plant of Java indigo of vertical habit

The following types of roots have up to the present been found :—

(1) *Early bush types* in which nearly all the lateral roots are at right angles and are concentrated near the surface.

(2) *Early types with a vertical habit* in which nearly all the lateral roots are concentrated near the surface but all point downwards.

(3) *Late bushy forms* in which there is a development of lateral roots from the surface to a great distance down the main root.

(4) *Late types of vertical habit* with lateral roots pointing downwards arising at regular intervals down the long main root.

(5) *Types with hardly any side branches* but a deep tap-root. These types scarcely branch at all either above or below ground.

It will be obvious that if aeration is of any importance the type which will thrive best in the monsoon in Bihar is type 1 and that type 2 will be the next best. Even if the lower portion of the root-system in these types is asphyxiated, the upper portion would be sufficient to carry on growth. Plants belonging to types 3 and 4 would lose a large portion of their root-system and even if they could struggle on would not thrive. Plants of the fifth type would be killed out. Experience shows that this is the case. Rapidly-growing, bushy indigos with most of the root-system near the surface, have successfully withstood the monsoon, while deep-rooting types belonging to classes 3, 4 and 5 have died out.

THE IMPROVEMENT OF COTTON CULTIVATION IN THE CENTRAL PROVINCES STUDIED FROM AN ECONOMIC POINT OF VIEW.

BY

D. CLOUSTON, M.A., B.Sc.,

Deputy Director of Agriculture, Southern and Western Circles, Central Povinces.

THE amount of literature available on the subject of the cotton industry in India is very considerable. The attempts made by Government from time to time to develop this industry fall under three heads: (1) Attempts to extend the cultivation of long-stapled cottons quite regardless of their out-turns; (2) attempts to improve existing varieties; and (3) attempts to breed new cottons so as to produce in the cross the good qualities of both parents. In the Central Provinces the first real effort made by Government to improve our cottons was in 1865 when in response to an appeal from Lancashire for more and better cotton, our Government appointed a Cotton Commissioner (1) to introduce long-stapled exotic cottons, (2) to extend the cultivation of the existing long-stapled indigenous variety called *bani* (*G. indicum*), (3) to increase the acreage under this variety by getting larger areas grown in the rice and wheat tracts, and (4) to improve the conditions under which cotton was marketed. The Cotton Commissioner was a member of the Indian Civil Service and a man of parts and did assist the industry at this time by introducing cotton presses and by improving the conditions under which the cotton was marketed; but his efforts to improve the quality or out-turn of the cotton grown were not successful. This is not surprising when we know that he neither professed to have an expert knowledge of the

subject of agriculture, nor had he any more highly qualified man to assist him than a trained gardener from home.

The numerous American and Egyptian cottons tried at this time did no good ; the distribution of seed of these and of hundreds of tons of *bani* among cultivators ended in poor yields, loss of customary profits and much heart-burning as the result ; for *bani*, as we know now, is one of the very poorest yielders of all the cottons grown in India, and its out-turn of lint to seed is lower than that of any other variety grown in this part of India.

American and Egyptian cottons have never done any good in the Central Provinces. With a rainy season extending from the middle of June till the end of September followed by a long spell of continuous dry weather, these comparatively long season cottons do not stand a ghost of a chance. They suffer from red leaf blight at the end of the rains and their growth is entirely checked later by the cracking of the soil and the consequent breaking of the roots. On the formation of a Department of Agriculture for the Central Provinces in 1883 the trial of these exotic cottons and of *bani* was again made, but with no greater measure of success than crowned the efforts of the Cotton Commissioner. When I came out to the Central Provinces in 1905 as its first agricultural expert they were still being tried on the Government Farm at Nagpur alongside of *bani* and *jari*, the latter being the name given to the mixed cottons of the *neglectum* type grown in these parts. No attempt had been made up to 1905 to single out the different cottons that constituted this mixture though it was obviously the only method of attacking the problem that could possibly be depended on to give satisfactory results. On classifying the cottons in 1906 it was found that our so-called *Jari* consisted of four distinct cottons, namely, *N. roseum*, *N. roseum cutchica*, *N. malvensis*, and *N. verum*, mixed with a percentage of *Bani* and Upland Georgian varying from about 10 to 15—Upland Georgian (*G. hirsutum*) being an American cotton of the Upland type which is supposed to have been introduced in the Provinces in the sixties. The percentage of each type in the *jari* mixture varied from district to district. In the north of the Provinces

the percentage of *roseum* and *cutchica*, the two white-flowered types, did not exceed two or three per cent.; while in Berar it varied from about 5 to 50. It was observed, moreover, that the percentage of lint to seed in this mixture varied directly with the percentage of the white-flowered types present. In the northern districts it was 31 to 32: in the districts of Berar it rose to as high as 35. On the borders of the Nizam's Dominions where *bani*, known there as *karkeli*, still reigned supreme, it fell to 26.

Experiments were started in 1907 on the Akola Farm to compare the out-turns of these different cottons which our classification had revealed. The average out-turns for a period of nine years are given in the table below:

Variety	Percentage of lint	Average out-turn of lint per acre in lb.	Value of lint at present prices
			Rs.
Roseum	40	214	93
Cutchica	38	201	87
Verum	32	147	64
Malvensis	32	138	66
Buri	33 – 34	128	67
Bani	25 – 26	103	54
Jari from Berar	34	158	69
Saugor Jari from C. P.	32	147	64

Roseum, one of the four *neglectum* types, has proved to be the best, in so far as it gives both the largest yield of *kapas* or unginned cotton and the highest percentage of lint to seed. Compared with *jari* which it is now fast replacing, it has given 56 lb. more of lint per acre, worth approximately Rs. 24 at present prices. It has given on an average 111 lb. of lint per acre more than *bani*, the long-stapled but low-yielding cotton which so many efforts had been made to push in the past. The quality of the lint of *bani* is much better than that of *roseum*, but its superior quality does not make up for its other outstanding defect, namely, its low yielding power, as the last column of the table will show.

Mr. Arno Smith Pearse, Secretary of the International Federation of Master Cotton Spinners and Weavers, had suggested after inspecting these cottons that the full market-value of

long-stapled varieties like *buri* and *bani* could only be obtained by selling them in England. At his suggestion samples were sent to firms at home for valuation. Their valuation showed that the lint of *bani* and *buri* was as good as Middling American, and was worth about ½*d.* per pound more than *roseum*, the value of *roseum* being 6*d.* a pound. It evidently would not pay, therefore, to market our long-stapled cottons at home, where the difference in price amounts to about 8 per cent. only, when in Nagpur we can get from 20 to 25 per cent. more for them than for our shorter-stapled *roseum*. But even making full allowance for the higher price paid for quality in Nagpur, none of the longer-stapled varieties has given anything like as large an acreage profit as *roseum*.

The superiority of *roseum* was so evident to the cultivators that the only difficulty experienced by the Department in getting it introduced as a pure crop has been in meeting the enormous demand for seed. For the last three years we have been distributing from 1½ to 2 million pounds of seed each year through our Co-operative Seed Unions and Seed Farms and the area under *roseum* at present must be at least 700,000 acres. Twelve of our leading land-owners of the cotton tract, who have been growing this variety for some years on areas varying from 300 to over 5,000 acres, were asked lately to state what extra profits its cultivation had given them per acre last year (1914-15). The average of their estimates worked out to over Rs. 16 per acre. The price of cotton has risen by over 50 per cent. since last year, and the profit from *roseum* should this season rise in proportion; but if we take Rs. 15 per acre as being the average gain this year—which is certainly a very modest estimate—the cotton growers and buyers of the Central Provinces and Berar will be benefited by their *roseum* to the extent of at least one crore and five lakhs of rupees—a sum which will more than cover the cost of our own Department twenty times over, and the cost of all the Agricultural Departments in India, including Burma, about twice over.

As soon as it became evident from our experiments on the Akola Farm that the introduction of *roseum* was to add largely to the wealth of the Provinces, the Department concentrated its

efforts in the cotton tract on the improvement and distribution of this one markedly prolific type. Had we instead devoted our attention to the introduction of exotic cottons or to the extension of *bani*, our indigenous fine-stapled variety, our efforts would have been none more successful than those of our predecessors.

A considerable amount of time has been given to the study of cotton pests and diseases, but only one of the several lines of investigation taken up has given results of any value, namely, the study of cotton wilt. Cotton wilt is a fungoid disease caused by one of the *Fusariums*. In some districts, more especially in Berar where cotton is grown on the best land year after year without a break, the disease does much damage in the areas infected. The cottons under trial were sown in pots filled with wilt-infected soil and the percentage of plants attacked in each was noted. It was found that *buri* cotton, one of the Upland type, was quite immune to the disease. The experiment was carried out on a large scale later in wilt-infected areas in the villages. In every case *buri* was found to be resistant, though a high percentage of the plants of the indigenous cotton, *jari*, succumbed to the disease as a rule. The resistance of *buri* to the disease is now well known to the cultivators and it is not unusual to find wilt-infected areas sown with a mixture of *roseum* and *buri*. In a bad wilt year the *buri* at least survives. Later investigations showed that it was not possible to get wilt-resistant strains of our *neglectum* cottons by selecting seed from plants which survived when grown in wilt-infected areas. Nor is the damage done by the disease reduced to any appreciable extent by rotating cotton with another crop.

It has already been pointed out that none of the exotic cottons tried could at all compete with *roseum*. The enhanced value of lint due to the staple being longer does not compensate for the considerably lower out-turn of lint per acre. Moreover, the lint of exotic cottons grown in the Central Provinces invariably deteriorates after a certain number of years. Our Upland Georgian has a distinctly weak fibre, due to its having been cultivated for about half a century under the unfavourable soil and climatic

conditions which obtain in these parts. As it offered little or no scope for improvement it has been discarded by the Department, and the cultivation of *buri*, the variety already referred to, taken up instead. *Buri*, though it has done distinctly better than Upland Georgian, takes too long to mature to thrive well in years in which the rains cease early. On the other hand, it does but poorly on all but the best soils, requiring as it does more manure and more moisture than our indigenous cottons. In a dry year its lint is weak.

With such a fine cotton as *roseum* ready to hand the possibility of producing a better by crossing seemed remote. Still a good deal of work in cotton-breeding has been done on the Government Farms in the cotton tract, and we now have two crosses under trial on a field scale. The one was obtained by crossing *bani* with a *neglectum* cotton from the Punjab ; the other by crossing *bani* with *roseum*. The lint of the former, now known as the Sindewahi cross, is nearly as good as that of *bani* and the percentage of lint to seed is about 36 ; while in the case of the *Bani-roseum* cross the percentage of lint is about 34, as against 26 and 40 respectively for its two parents. It is a comparatively easy matter by crossing *bani* with one of the more prolific but shorter-stapled *neglectum* cottons to get a cross of medium quality ; but it is extremely difficult to produce one with a high percentage of lint of good quality. When the staple of the cross is long the percentage of lint to seed is low ; when the percentage of lint is high the staple is as a rule short. Quantity of lint counts for more than quality and unless we can produce in our crosses quantity as well as quality, all our efforts to improve the economic condition of the cotton grower will be in vain. The Sindewahi cross gives 36 per cent. of lint to seed and its lint is worth about ½*d*. a pound more than *roseum*, which is equivalent to a gain of approximately 8 per cent. when prices are normal ; the loss of about 4 per cent. in the percentage of lint is therefore more than covered by this improvement in quality. On the other hand, it has yet to be proved that this cross will, when grown under the same conditions, produce as much *kapas* per acre as *roseum*.

In the Central Provinces cotton is never irrigated, our black cotton soil not being well suited for irrigated crops. Of the cotton soil area there are about $4\frac{3}{4}$ million acres under cotton, scattered over 8 different districts in which the rainfall does not exceed 45 inches per annum. In this cotton soil area, therefore, the rainfall is the factor which determines whether cotton can be grown profitably or not. We have lately proved by experiment that with irrigation it can be grown very profitably on our red laterite soils with an annual rainfall of nearly 60 inches. There are hundreds of thousands of acres of this *bhata* land lying waste in Chhattisgarh at present, which being porous and therefore free from water-logging would appear to be well suited for cotton despite the heavy rainfall of the tract. Yields of over 1,000 lb. of *kapas* have already been obtained by the Department on this poor but well-drained land which in the past has always been considered too wet for cotton. This information is likely to be of very considerable economic value in those parts of the Central Provinces outside the cotton belt where large stretches of waste *bhata* land are now being brought under irrigation as a result of the completion of certain Government irrigation works. In these soils the cost of weeding is a mere fraction of what it is in black cotton soils for the reason that all our most troublesome species of weeds, which thrive so well on heavy soil, fail to establish themselves on the *bhata* owing to its dryness in the hot weather. All our experiments on such soils show the enormous importance of good drainage and aeration for irrigated cotton. The fertility of the soil is of very secondary importance : it can be added at a small cost by applying dressings of bulky organic manure, such as cattle-dung or sunn-hemp. For irrigated crops in short the soil is merely a medium, the productiveness of which is largely dependent on three factors, namely, drainage, aeration, and the presence of plenty of organic matter.

Our present position with regard to cotton improvement in the Central Provinces then is that by the discovery of *roseum* we have greatly improved the economic condition of the cotton cultivator. We have produced thousands of crosses, between *bani*

and shorter-stapled *neglectum* cottons. One of these crosses has done very well in the Central Provinces and is now being tried in Bombay and the States of Central India. *Buri* is entirely wilt-resistant, but it is only in years of prolonged rainfall that it can be depended on to yield well. Under irrigation cotton has, on light laterite soil most of which is at present lying waste, given much better yields of *kapas* than on our heavy black soil. Our main work for the next few years will be (1) to get *roseum* grown over the whole cotton tract except in the relatively small wilt-infected areas; (2) to improve it by selection; (3) to give our most promising cross a thorough trial under field conditions not only in the Central Provinces but in other parts of India where the soil and climatic conditions are similar to what they are here; and (4) to get the cultivation of cotton introduced in the irrigable *bhata* areas of the rice tract which are at present lying waste.

The improvement of *roseum* and *buri* by selection has already been going on for the last seven years, during which time our main aim has been to increase the ginning percentage of selected strains by selection every year from pure line sowings. It has been amply proved that when the seed of any one mother plant giving a high percentage of lint is sown, the offspring taken collectively inherits the character of giving a high percentage of lint, though the percentage given by different plants of this strain varies.

The small variation in the percentage of lint from year to year from any one strain would appear to depend very largely on two factors, namely. soil and rainfall. Other things being equal, the deeper and more retentive soils give the higher percentage. In a good cotton season when the rainfall has been well distributed the percentage over the whole cotton tract is about 1 per cent. higher than in a bad year. The percentage of lint obtained from different pickings of the same strain also varies, that of the first and last pickings being from 1 to 2 per cent. less than that of the second and third. This, I believe, is due to the fact that the first and last pickings contain bolls damaged by boll-worm as well as some immature cotton. If by the method at present being

followed we could by selection increase the ginning percentage of our cotton by even 1 per cent. we would thereby increase the profit on its cultivation by R. 1-8 per acre, which over an area of $4\frac{3}{4}$ million acres would amount to approximately 70 lakhs of rupees.

THE SCIENCE OF FORESTRY.

BY

CECIL E. C. FISCHER,

Principal, Madras Forest College, Coimbatore.

THANKS to her geographical situation and to the fact that no part of her lands is far from the ocean, Great Britain has not had her lamentable lack of forests forced into prominence, as has been the case with less fortunate countries. Consequently, forestry has been neglected in the British Isles, and it is only a great crisis, such as the present war, that proclaims our weakness in this matter. Fortunately, this deficiency lies in the direction of finance and shortage of timber, and it is not in the more permanent aspect of their rôle of protectors of the land against natural calamities that the want of forests has made itself felt.

It is true that there was some agitation in favour of plantations in the seventeenth century and a certain amount of planting and sowing of oak was actually carried out, but this was without system and the impulse soon died away. It was prompted almost solely by the fear of a dearth of oak timber for naval construction.

Though similar reasons inspired a policy of forest preservation in France at about the same period, other causes militated in favour of its permanency and towards the evolution of a definite system of forestry. Other Continental countries sooner or later adopted similar measures, and the force of circumstances has made the conservation and extension of forests, especially in the mountainous regions, a matter of absolute necessity. Prejudice had to be overcome, and it is not without set-backs that the present stability, still threatened in places, of the forest policy has been established in most European lands.

Gradually defined systems of management were evolved. From these first beginnings has arisen a scientific sylviculture, based on continuous and patient research, which demands close observation and trained administration for its control.

Until recent years England has had little to do with this development, and to this day forestry is hardly more than a name within the confines of the United Kingdom. This is not for want of preaching! Amongst others, but chief among them, Sir William Schlich, formerly Inspector-General of Forests in India and now Professor of Forestry at the University of Oxford, has urged the great desirability of extending the British forests and of managing them on methodical, scientific lines. The shortage of British-grown timber has been emphasized by the demand of the war now being waged, and no doubt this blot on British statecraft will be effaced when normal conditions have been restored.

India, happily, was more fortunate in this regard. Attention was paid to the forests of India so early as 1847, partly with a view to better exploitation, partly to ensure their conservation and improvement.

Since that date the Department, first manned mainly by specially deputed military officers and later by trained foresters, has grown to its present size and scope. India has had the benefit of the services of not a few distinguished scientists in her Forest Service and three of them have had the honour of the Fellowship of the Royal Society conferred upon them.

It is particularly in lands like India that forestry is of importance, not only on account of the geographical and climatic conditions, but because the population is dependent mainly on agriculture, for which a regular supply of water is essential.

Apart from questions of limitation of time, it would be an impertinence on my part to attempt to go into details before such an audience of the effects of forests on climate and topography and the resulting importance to any country. It will not be out of place, however, to recapitulate shortly the directions in which such benefits are bestowed and for which there is ample proof in this as well as most other lands.

It is still a controversial point whether forests do or do not increase the total rainfall, but there can be no question that atmospheric humidity is increased and rainfall is more generally distributed during the year where forests exist.

The transpiration from the leaves, the greater radiating surface, the protection of the soil from insolation and evaporation, conduce to greater coolness and freshness in and around the forest during the hours of sunlight and more warmth at night; in short the extremes of temperature are moderated.

Forests form also an effective protection against winds, both in breaking their violence and in preventing desiccation by hot dry winds or damage by icy blasts in glacial latitudes.

The rôle of forests in stabilising loose slopes, preventing erosion, and silting up of rivers and estuaries, in precluding the occurrence of avalanches and landslips, is well known. They alone offer a permanent remedy for such evils.

It is recognized in France and Switzerland, as the result of careful observations carried out over a long period of years, that even small areas of woodlands are instrumental in preventing the formation of hail, or at least in very greatly reducing the violence of hailstorms.

Belts of trees offer a more certain barrier to epidemic diseases than sanatory cordons. In a large number of instances plantations have converted pestilent swamps into normally healthy districts and in some cases even into sanatoria.

But, on the whole, the greatest service rendered to humanity by forests is in regard to water, and this in two directions. Firstly, by the storage of water, so that it is prevented from rushing down the slopes to the valleys and the sea to be lost to agriculture. The forest acts, in a way, as a sponge which holds up the water and parts with only gradually, maintaining the springs more or less perennial. Secondly, by obviating disastrous floods. A careful investigation into the circumstances of inundations will reveal, in practically every instance, the fact of a lack of vegetation at the crucial point. Here not only agriculture but industries dependent on water power are at stake since they suffer through both flood and drought.

It must be clear then that agriculture is indissolubly bound up with forestry. Indeed, it is not too great a claim to put forward that without forests there would be no agriculture and very little life on the terrestrial part of the globe. With the spread of civilization and all that it entails in demands on the forests and in the removal of forest growth, sooner or later a strict conservation of the forest resources becomes absolutely essential. The vital importance of forest science to this country and to our world as a whole, therefore, needs no further emphasis. It is not merely to obtain the direct benefits derived from forest products that the methodical working of the forests is necessary but equally, if not in greater measure, to secure the indirect benefits of protection.

Until recent years foresters in India have had to rely on the research and observations made in Europe and to adopt European methods. Gradually a feeling has spread that these methods are not entirely suitable to the tropics. With the installation of a Research Institute at Dehra Dun some progress has been made towards the evolution of more applicable systems or modifications of the old systems, but it is clear that one such institute cannot suffice for so vast and so varied an area as is comprised within the Indian Empire. It is hoped that before long another forest research institute for Southern India will become a concrete fact.

Foresters are very commonly asked: "What is forestry? What do you do to protect your forests?" The best answer that I have heard lies in the words of Ex-president Roosevelt: "Conservation by a wise use!" Forest science is based fundamentally on such phenomena as the struggle for existence; heliotropism; the retarding effect of light on growth; the necessity of light, heat, moisture, and air for satisfactory plant development. Utilizing these natural laws the forester seeks to hasten the growth and increase the proportion of the more useful species and to fully stock the areas available so as to obtain the maximum yield for the locality.

One of the essential features of forestry is that the forester works for the future rather than the present, and his first aim is to secure the young growth that will ensure the continuity of the forest.

Seeing that the life of a forest tree may be anything from 30 to 200 or more years, it is rare for a forester actually to see the harvest of the crop he has created. It is patent that this condition must add to the difficulty of rectifying errors and of profiting by experimental research.

Though scientific forestry has made very considerable strides in recent years in India, it is still merely on the threshold and there are many difficult problems before it.

It has not been my object in preparing this paper to give anything like a comprehensive account of my subject, and if I have succeeded in exciting some interest and in gaining recognition by the Council of the Indian Science Association for the science of sylviculture, I shall have achieved all that I could hope for.

CHALYBEATE WATERS FROM TUBE-WELLS IN THE PUNJAB: THEIR SIGNIFICANCE TO THE MUNICIPAL ENGINEER AND TO THE MANUFACTURER.

BY

J. H. BARNES, B.Sc., F.I.C.,

Principal, Punjab Agricultural College, and Agricultural Chemist to the Punjab Department of Agriculture,

AND

ARJAN SINGH, L.Ag.,

Research Assistant in Chemistry in the Punjab Agricultural College.

I. Preface.

The recent introduction of tube-wells and power-pumping machines into India, and the consequent tapping of a deeper water-supply than that hitherto available through the medium of the shallow surface well, has brought the water engineer face to face with an unsuspected problem and one which materially affects the financial aspect of the use of such wells for supplying water to large cities or to the factories of certain trades.

The presence of iron in solution in chalybeate spring water has been known for many centuries and made use of for medicinal purposes. Well water which has been derived from a ferruginous sand, mountain limestone, and even chalk beds, often contains so much iron in solution that the water becomes turbid and brown when exposed to the air. The iron so contained in solution is in the form of a ferrous carbonate and its presence is always associated with carbon dioxide in solution. The reducing action which must

accompany the oxidation of organic matter in solution when out of contact with air, may account for the presence of iron in the ferrous state and in the form of a carbonate ($FeCO_3$). It can exist in solution as such only so long as the water is kept out of contact with air and so long as the solution is acid with carbonic acid. As soon as a highly ferruginous water is exposed to the air, a gaseous exchange takes place which results in the escape of carbon dioxide from solution and the absorption of atmospheric oxygen. It is this oxygen which brings about the precipitation of the iron as a hydrated oxide of iron ($Fe_2O_3 \cdot 6H_2O$). The precipitation of large masses of this compound leads to the formation of the mineral *limonite.*

The presence of iron in underground waters in Germany and the Netherlands has been the cause of exhaustive enquiries into this subject. A summary of these by Schwers is to be found in the *Revcu d'Hygiene*, volume XXX, 1908. With a few exceptions such as Cuxhaven, Griefswald, etc., the underground waters of North Germany and of Holland are freely charged with iron. Springs near Bremen have as much as 85 parts of iron per million; those at Posen above 14·25 parts per million; the Berlin-Tegel and Kiel supply about 1·7, while it is somewhat less than this in Hanover. Many of the underground waters of the Netherlands contain iron, in particular the dune waters, which vary from 0·8 to 28·5 parts of iron per million and many water stations in Holland are equipped with deferrization plant in addition to machinery for water purification. This type of water is common in the United States, and there are several supplies of consequence in Great Britain which contain iron in solution. They occur also in France and Belgium. We may therefore state generally that ferruginous waters are fairly widely distributed.

The use of such waters for municipal purposes is accompanied by several grave disadvantages. In the first place though the iron even in the more heavily impregnated waters is unlikely to detrimentally affect the public health, the turbidity of the water and the constant staining of glass and other vessels used for storing it, leads to uneasiness on the part of the public as to its purity and suitability for potable use.

The deposits of hydrated oxide of iron tend to accumulate in storage reservoirs and mains, causing a loss of carrying power in the latter and involving expenditure on cleaning in the former. This causes them to be regarded with disfavour by the engineer and with suspicion by the public, but it often happens that no other water is available for use and steps have to be taken accordingly to remove the iron from solution before passing the water into the mains. This involves an additional outlay in capital and extra expenditure on maintenance in the waterworks machinery, and where this is the case the costs should be reduced to a minimum by removing only that amount of iron which is necessary in order to prevent (*a*) growth of rust in the pipes and (*b*) turbidity in the water itself. How far iron purification has to be carried in order to achieve this, has fortunately been worked out for us on the continent of Europe, and we are justified in assuming that the standard there laid down will suffice for Indian conditions, since the same organisms are found to be present in well water derived from tube-wells in the Punjab as are present in the chalybeate waters of other parts of the world.

Among the higher bacteria is to be found a class of organisms which almost always inhabit ferruginous waters. As a result of their growth and decay their membranes become impregnated with ferric hydroxide extracted from the water in which they are growing, giving them a rusty red appearance. These are the iron bacteria of Winogradsky.

It is not necessary for us to consider here the various theories relating to the physiology of the iron bacteria; a full discussion of their relative merits will be found in an article by Ellis in *Science Progress*, January, 1916. We are concerned chiefly with the question of what is the greatest amount of iron which a water may contain without becoming a fruitful medium for the growth of these organisms which act as iron precipitants. According to Schwers, deferrization should be as complete as possible and the filtrate should not contain more than 0·1 part of iron per million. This author records cases of iron precipitation in the mains at Leipzig, Slade, Posen, and Munich-Fladbach when the purification

has been less than this. *Crenothrix polyspora* will flourish in a solution of 0·3 part of iron per million.

It is a matter of experience that waters containing much iron are more easily purified than waters which contain smaller amounts. Don and Chisholm state that at Kiel the purification process removes 95 per cent. of the iron out of a water containing 1·3 parts per million; while with the same method of treatment at Hanover dealing with a water containing only 0·25 part of iron per million, the efficiency of the process is only 50 per cent. The nature of the saline contents of the water would materially affect the efficiency of the treatment.

The methods of purification vary but are for the most part aeration followed by filtration—aeration first to remove the carbon dioxide from solution and then oxidize the ferrous carbonate and cause its precipitation as hydrated oxide of iron, and filtration to remove this. In some cases the oxidation is aided by the use of chemical accelerators or catalysts. Iron filings and coke impregnated with an iron salt have been used. Sometimes by the addition of electro-negative ions to neutralize and precipitate the electro-positive ions of colloidal iron, such as chalk mixed with sulphate of alumina and even clay. An elaboration of this system of purification includes the use of sedimentation tanks in addition to ordinary filtration by sand.

In 1916 our attention was drawn by the Sanitary Engineer to Government to the water obtained from two tube-wells in Dera Ghazi Khan. These two wells had been sunk side by side to test the relative merits of two different types of strainers—the Ashford and Brownlie strainers. This water is used for municipal purposes and, very soon after the pumps had been in operation, began to show marked signs of turbidity and iron deposit. A preliminary examination of these and other tube-well waters in the province shows them all to contain such amounts of reduced iron as to render it certain that they will give trouble in the near future. The enquiry was subsequently extended to include water samples from deep wells of this type throughout the Punjab in order to obtain information relating to the absorption of iron by the water as well as to see where the best and worst waters were to be found.

II. METHODS OF ANALYSIS.

As the enquiry specially aims at a knowledge of the *condition* as well as the *amount* of iron in the water, an examination was first made of the various colorimetric methods of estimating iron in solution. These are (*a*) the production of a blue colour when the ferric salt is brought in contact with a solution of potassium ferro-cyanide, (*b*) the production of a black colour when the ferrous salt is brought in contact with ammonium sulphide solution (*Winkler Zeit für Anal. Chem.* 1902, XII, 550-553, *Analyst*, XXVIII, 1903, page 16, Lunge and Keane's *Technical Methods of Chemical Analyses*, part II, page 773), (*c*) the production of a blood red colour when solutions of a ferric salt and potassium thiocyanate are brought in contact, and (*d*) a blue colour when solutions of a ferrous salt and sodium phosphotungstate are mixed and made alkaline with sodium hydroxide (*Analyst*, XXXIV, 1909, page 239). (*b*) and (*c*) were finally selected as suitable and giving results of sufficient accuracy for the purpose in view. In using these methods, a freshly prepared solution containing 0·1 mg. of ferrous iron per cc. is made by dissolving 0·7 gram of pure ferrous ammonium sulphate in recently boiled and cooled water and a few drops of sulphuric acid added. This gives a deep brown colour with ammonium sulphide solution. With 1/20th strength, *viz.*, 0·005 mg. of ferrous iron, the dark colour of the sulphide of iron is still perceptible. With ferric iron the reaction is much less sensitive, being masked by the production of sulphur, consequent on the reduction of the ferric salt to the ferrous state. In making the test 100 cc. of water are placed in a Nessler tube, 5 cc. of hydrogen sulphide water and a few drops of ammonia are added; 100 cc. of distilled water are now placed in a second tube and similarly treated, the standard solution of ferrous ammonium sulphate being added from a burette with constant agitation with a glass rod until a tint of nearly equal density is obtained. The exact matching of the tints cannot be accomplished since the former is brown and the latter is bluish-black. To the latter solution two or three drops of dilute hydrochloric acid are added and, after decolorization has taken place, a few drops of ammonia. More of the standard iron solution is now added until an exact match in tints is obtained.

Lastly both solutions are decolorized with hydrochloric acid and afterwards made alkaline with ammonia when the colours in the two tubes should exactly correspond. If they do not, more or less of the standard ferrous iron solution should be used and the process repeated until an exact match of colours is obtained. From the amount of the standard iron used we can then readily calculate the quantity of ferrous iron present in the water. To obtain accurate results, the amount of ferrous iron in the water should be between the limits of 0·3 and 1·5 mg. per litre ; if less than 0·3 mg. per litre are present 500 cc. of the water sample should be taken for the test and if more than 1·5 a correspondingly smaller quantity taken and diluted with distilled water.

Iron in the ferric condition is determined after reduction to the ferrous state by hydrogen sulphide. 10 to 500 cc. of the water, according to the amount of iron present, are made acid with hydrochloric acid and evaporated to dryness—the residue taken up with water and a little hydrochloric acid, and treated with hydrogen sulphide solution and heated for a few minutes in a water bath, filtered, and tested for ferrous iron in the manner described above. This method is of advantage for determining the total amount of iron since the condition of the test maintains the salt in the ferrous state and so obviates any conversion of ferrous to ferric iron. When using the potassium or ammonium thiocyanate test, all the iron present in the water must first be converted into the ferric salt. Similarly the standard solution of ferrous ammonium sulphate is converted into the ferric state. This conversion can be effected by (*a*) evaporation with potassium chlorate and hydrochloric acid or (*b*) by evaporation with a little nitro-hydrochloric acid.

250 cc. of a solution of ferrous ammonium sulphate containing 0·1 mg. of iron per cc. are evaporated to dryness with 0·2 gm. potassium chlorate and 3 cc. of strong hydrochloric acid (2 cc. nitric acid free from iron and 3 cc. of hydrochloric acid will do equally well). The residue is taken up with water containing a few drops of sulphuric acid and diluted to 250 cc. 1 cc. then contains 0·1 mg. of iron in the ferric state.

In carrying out the analysis, the ferric iron present in the water is determined first, the ferrous iron is then oxidized and a second estimate made of the total ferric iron present, the difference gives the ferrous iron in the sample. Into a Nessler tube are placed x cc. of the standard ferric sulphate (1 cc. equal to 0·1 mg. of Fe) diluted with water and 4 cc. of a 15 per cent. solution of potassium thiocyanate added and well mixed. 100 cc. of water are then mixed with 4 cc. of the thiocyanate solution and the tint in the two tubes matched by the ordinary methods. This gives the amount of ferric iron present. In order to determine the ferrous iron, 100 cc. of the water (or 500 cc. if the water contains a small amount of iron) are placed in a porcelain basin with 2 cc. of nitric acid and 3 cc. of hydrochloric acid and evaporated to dryness and the residue taken up with acidulated water and made up to the original volume. The total amount of ferric iron is now estimated in the manner described above. The difference between the two figures so obtained gives the amount of ferrous iron present. The following tables show the degree of accuracy obtained by using these two methods :—

TABLE I.

Showing the results obtained by the thiocyanate method.

Milligrams of iron calculated		Milligrams of iron found			Remarks
Ferric	Ferrous	Ferric	Ferrous	Total	
nil	0·005	nil	0·0050	0·0050	Ferrous alone.
nil	0·010	nil	0·0100	0·0100	
0·005	nil	0·0048	nil	0·0048	Ferric alone.
0·005	nil	0·0050	nil	0·0050	
0·010	nil	0·0100	nil	0·0100	
0·005	0·005	0·0049	0·0051	0·0100	Mixtures containing either excess of ferric or an equal amount of ferrous to ferric.
0·005	0·005	0·0050	0·0050	0·0100	
0·010	0·030	Not estimated	nil	0·0410	
0·050	0·005	0·1000	nil	0·1000	Mixtures where ferric predominates over ferrous.
0·250	0·100	0·3100	0·0350	0·3450	

TABLE II.

Showing the results obtained by the ammonium sulphide method.

Milligrams of iron calculated		Milligrams of iron found	REMARKS
Ferrous	Ferric	Ferrous	
0·09	nil	0·090	Ferrous alone.
0·02	nil	0·019	
0·01	nil	0·010	
0·03	0·01	0·034	Mixture of ferrous and ferric.
0·05	0·01	0·054	

From these tables, it is evident that the thiocyanate method is satisfactory when dealing with waters in which the ferric salt does not predominate over the ferrous. When ferric salts are present in excess of ferrous the results are unreliable, and it is advisable to estimate the ferrous salt by the ammonium sulphide method. In all the analyses detailed below both methods have been used as a check because the presence of the ferrous salt is the important factor in the enquiry. Since nearly all the waters contain ferrous salts in excess of ferric, the thiocyanate method is satisfactory. A modification of the method of oxidizing the ferrous salts for analysis by the thiocyanate method was introduced later as it was found to fulfil the conditions noted above. This method consists of boiling the water sample with 0·5 per cent. of nitric acid for 15 minutes, cooling, making up to the original volume with distilled water and treating with potassium thiocyanate solution.

III. THE COMPOSITION OF WATERS DERIVED FROM TUBE AND OTHER WELLS IN DIFFERENT PARTS OF THE PUNJAB.

In carrying out the chemical examination of these waters, it is of course essential that the analysis should be conducted on the water as it exists in the bed from which it is drawn; it must not be allowed to stand after pumping, since oxidation of ferrous salts may then take place. We have also to take into consideration the fact that iron machinery and tubes are used for extracting the

water from the soil. The samples of water, therefore, must not have been in contact with either tube or pump for a longer period than is necessary. To obviate these two difficulties, the pump is allowed to run for half an hour previous to sampling and the analysis of the water conducted on the spot. At the same time the waters from a number of ordinary country wells were examined in the same localities so as to see the difference between the composition of these and the water drawn from the deeper strata.

Five of the larger towns of Northern India were chosen for the investigation, these were all places where tube-wells are established and the water from them is being used for municipal purposes.

The enquiry commenced in April 1916 with the examination of waters from Dera Ghazi Khan, Sialkot, Amritsar, and Lahore, and the following results were obtained. (Tables III and IV.)

TABLE III.

Showing the composition of two tube-well waters from Dera Ghazi Khan (Ashford and Brownlie strainers).

Type of well strainer used	Parts per 100,000							
	Total solids	Total chlorine	Total chlorides as sodium chloride	Total sulphates as sodium sulphate	Total carbonates as sodium carbonate	Total bicarbonate as sodium bicarbonate	Permanent hardness as calcium carbonate	Temporary hardness as calcium carbonate
Ashford ..	130·4	9·93	16·3	84·5	0·56	13·5	20·0	23·0
Brownlie ..	111·5	9·85	16·2	68·2	0·42	18·9	15·0	29·5

With the single exception of the open well of the Amritsar waterworks (*see* Table IV), all these waters contain an amount of iron which according to Schwers will necessitate deferrization in order to avoid the precipitation of iron oxide in the mains.

The low iron content of this water sample (No. 5, dated 12th April 1916) is due to two causes : (*i*) The nearness of the water table to the surface which admits of freer oxidation and (*ii*) the large

TABLE IV.

Showing the composition of well water in April 1916.

Number and date of the sample	Description	Iron parts per million: Total	Ferric	Ferrous	Control Ferrous iron parts per million (ammonium sulphide method)
1 4-4-16	*Dera Ghazi Khan*, tube-well, Ashford strainer	1·070	nil	1·070	1·100
2 5-4-16	*Dera Ghazi Khan*, tube well, Brownlie strainer	1·060	nil	1·060	1·120
3 8-4-16	*Sialkot*, tube-well, Ashford strainer	0·840	0·36	0·480	0·480
4 10-4-16	*Lahore*, tube-well, Brownlie strainer	0·730	0 18	0 550	0 560
5 12-4-16	*Amritsar* waterworks, open well ..	0 091	nil	0·091	0·100
6 12-4-16	*Amritsar* waterworks, open well, with Brownlie tube ..	0·210	nil	0·210	0·240
7 12-4-16	*Amritsar* waterworks, open well, bottom concreted with Brownlie tube	0·205	nil	0·205	0·203
8 14-4-16	*Amritsar*, Katushah *Kot-saidmud* Brownlie tube-well ..	0·250	nil	0·250	0·250

amount of water pumped at the waterworks which likewise assists in aerating the soil.

This is clear from the following table :—

TABLE V.

Showing the distance of the water table from the surface and the average daily discharge of wells mentioned in Table IV.

Place	Daily consumption of water in 1915 16	Number of wells connected in the installation	Type of surface soil	Distance of water table from the surface
Dera Ghazi Khan	74,000 gal.		First 20 feet of clay	Ft. 30·0
Sialkot ..	250,000 gal.	6	Loam	46·0
Lahore ..	Not given	1	Light loam	24·0
Amritsar ..	1,700,000 gal.	40	Do.	12·5

In the high pressure storage reservoirs at Dera Ghazi Khan, there was a large fungus-like deposit of ferric oxide in which a number of the iron bacteria could be recognized.

This preliminary enquiry having demonstrated that deep well waters in the Punjab are commonly impregnated with iron in the ferrous state, the observations were continued at the end of the monsoon (September) with the object of ascertaining if any marked change is noticeable in the amount of iron present in the waters at the end of the rainy season when the water table is at its highest. The enquiry was also broadened to include more wells in the cities first examined as well as the town of Ambala. The results so obtained are given in the following Tables VI—X.

TABLE VI.

Showing the composition of well waters at Ambala.

Number and date of analysis	Description of sample	Iron parts per million (thiocyanate method)			*Control* Ferrous iron parts per million (ammonium sulphide method)	Type of iron bacteria observed to be present
		Total	Ferric	Ferrous		
1 19-9-16	Percolation well (grain market) ..	0·13	Absent	0·13	0·12	nil
2 19-9-16	Percolation well (Manaoli House) .	0 06	Do.	0·06	0 06	nil
3 19-9-16	City reservoir iron tank ..	0·73	0·43	0·30	0·30	*Leptothrix ochracea.*
4 21-9-16	Mixed tube and percolation (waterworks) ..	1·06	0·77	0·29	0 29	*Leptothrix ochracea.*
5 21-9-16	Tube-well (waterworks) ..	0·64	0·33	0·31	0·31	nil
6 21-9-16	Percolation (waterworks) ..	0·10	Absent	0·10	0·10	nil
7 22-9-16	Water from 27 wells, mixed tube and percolation ..	0·71	0·16	0·55	0·56	nil
8 22-9-16	Water from 5 percolation wells, Cantonment supply .	0·58	0·21	0·37	0·35	nil

Note:—

(1) Ordinary percolation well in grain market.
(2) Ordinary percolation well in Manaoli House *viâ* Bans Street.
(3) City reservoir iron tank.
(4) Mixed tube and percolation well No. 1, at Handosra waterworks.
(5) Tube-well No. 10, at Handosra waterworks.
(6) Tube-well No. 10, at Handosra waterworks. Sample taken from percolation streamlet through a crack in the masonry steining below spring level, while the well was being pumped.
(7) Discharge from main after leaving the pumps at Handosra waterworks.
(8) Ambala Cantonment water-supply, situated on Tangrá Nálá; water coming to the Cantonment by gravitation flow.

TABLE VII.

Showing the composition of well waters at Amritsar.

Number and date of analysis	Description of sample	Iron parts per million (thiocyanate method)			*Control* Ferrous iron parts per million (ammonium sulphide method)	Type of iron bacteria observed to be present
		Total	Ferric	Ferrous		
9 24-9-16	Percolation well (Bazaar) ..	0·065	Absent	0·065	0·060	nil
10 24-9-16	Percolation well (Railway)		Do.	0·090	0·080	nil
11 24-9-16	City reservoir iron tank	0·100	Do.	0·100	0·100	nil
12 25-9-16	Water from 40 wells, mixed tube and percolation ..	0·092	Do.	0·092	0·100	
13 25-9-16	Percolation well (waterworks) ..	0·070	Do.	0·070	0·070	nil
14 25-9-16	Mixed tube and percolation well ..	0·265	Do.	0·265	0·250	nil
15 25-9-16	Tube well (waterworks) .	0·170	Do.	0·170	0·175	nil
16 26-9-16	Tube well (Canal Department) ..	0·180	Do.	0·180	0·170	nil

Note :—

(9) Ordinary percolation well of Ferozdin, Honorary Magistrate, Hall Bazaar.

(10) Ordinary percolation well of Phaggu Mal near Railway bridge.

(11) City reservoir iron tank.

(12) Discharge from main (from 40 wells mixed tube and percolation) after leaving the pumps at waterworks.

(13) Percolation well No. 1, Delhi line at waterworks.

(14) Mixed tube and percolation well No. 1, Pathankote line at waterworks.

(15) Tube-well No. 28, Pathankote line at waterworks.

(16) Tube-well of Irrigation Department at Mr. Ashford's bungalow.

TABLE VIII.

Showing the composition of well waters at Lahore.

Number and date of analysis	Description of sample	Iron parts per million (thiocyanate method)			Control Ferrous iron parts per million (ammonium sulphide method)	Type of iron bacteria observed to be present
		Total	Ferric	Ferrous		
17 28–9–16	Mixed tube and percolation ..	0·135	Absent	0·135	0·135	nil
18 28–9–16	Percolation well ..	0·070	Do.	0·070	0·075	nil
19 28–9–16	Percolation (very old well) ..	0·165	0·165	Absent	Absent	*Leptothrix ochracea*
20 28–9–16	Water from 22 wells, mixed tube and percolation ..	0·395	0·240	0·155	0·170	nil
21 29–9–16	Main city reservoir (iron tank) ..	0·130	Absent	0·130	0·170	nil
29–9–16	Reservoir at Mozang (iron tank) ..	0·105	Do.	0·105	0·110	nil
23 29–9–16	Tube-well	0·140	Do.	0·140	0·170	nil
24 29–9–16	Tube-well	0·040	Do.	0·040	0·045	nil
25 11–10–16	Percolation well (Dabbi Bazaar)	0·075	Do.	0·075	0·080	nil
26 11–10–16	Percolation well (Anarkali) ..	0·062	Do.	0·062	0·060	nil

Note :—

(17) Badami bagh waterworks well No. 15, mixed tube and percolation.

(18) Badami bagh waterworks well No. 2, deep percolation.

(19) Badami bagh waterworks No. 2, very old, shallow but wide percolation well. There is no record in any office about the date of construction, etc., of the well; the local opinion is that the well was made in the Mahomedan Raj.

(20) Discharge from main near Engine House at waterworks, Badami bagh.

(21 & 22) They contain small grains of rusty black scales as suspended impurity.

(23) Tube-well sunk by Mr. Longdin, Lawrence Gardens.

(24) Tube-well, Electric Supply Company, Lahore.

(25) Ordinary percolation well, Bowli Sahib.

(26) Ordinary percolation well near Bible Society, Anarkali.

TABLE IX.

Showing the composition of well waters at Sialkot.

Number and date of analysis	Description of sample	Iron parts per million (thiocyanate method)			*Control* Ferrous iron parts per million (ammonium sulphide method)	Type of iron bacteria observed to be present
		Total	Ferric	Ferrous		
27 12-10-16	Tube-well ..	1·080	0·37	0·710	0·710	nil
28 12-10-16	Water mixed from 6 tube-wells ..	0·610	0·30	0·310	0·315	nil
29 12-10-16	City reservoir cement tank ..	0·370	0·21	0·160	0·160	nil
30 13-10-16	Tube-well ..	0·750	Absent	0·750	0·720	nil
31 13-10-16	Percolation well ..	0·095	Do.	0·095	0·110	nil
32 13-10-16	Percolation well ..	0·090	Do.	0·090	0·100	nil

Note :—

(27) Tube-well No. 4 at waterworks. Discharge poor.
(28) Water in the main after leaving the pumps at waterworks.
(29) City reservoir cement tank.
(30) Tube-well No. 6 at waterworks. It gives a high discharge.
(31) Ordinary percolation well, Khojian Street.
(32) Do. Kharasian Street.

Table X.

Showing the composition of well waters at Dera Ghazi Khan.

Number and date of analysis	Description of sample	Iron parts per million (thiocyanate method)			Control Ferrous iron parts per million (ammonium sulphide method)	Type of iron bacteria observed to be present
		Total	Ferric	Ferrous		
33 29-10-16	Tube-well ..	0·825	Absent	0·825	0·83	nil
34 29-10-16	Mixed water of two tube-wells ..	0·730	Do.	0·730	0·76	nil
35 30-11-16	City reservoir ..	0·680	0·18	0·500	0·50	(1) *Leptothrix ochracea* (2) *Gallionella ferruginea* (3) *Spirophyllum ferrugineum*
36 30-11-16	Percolation well ..	0·205	Trace	0·205	0·18	nil
37 30-11-16	Percolation well ..	0·280	Absent	0·280	0·30	nil

Note :—

(33) Tube-well (Brownlie), waterworks, D. G. Khan.
(34) Discharge from main after leaving the pumps, mixed water of two tube-wells.
(35) City reservoir (iron tank) near District Courts.
(36) Ordinary percolation well of Raja Ram near Sessions Court.
(37) Ordinary percolation well of Khákiwala near Rest house, P. W. D.

The results show (Table XIII) that on the whole the amount of iron in the sub-soil water is rather less at the end of the summer rains than at the end of the cold weather. It is also evident that the wells situated farthest from the Himalayas—the source of all the sub-soil water of the Punjab—contain the greatest amount of ferrous iron in solution. This is independent of the distance of the water table from the surface of the soil when water is drawn from some distance below the surface of the water table itself, *viz.*, by means of tube-wells and strainers. We can only account for this by the reduction of ferric salts, probably colloidal limonite (hydrated sesquioxide of iron). This reducing action is probably accelerated

by the presence of chlorides which will assist in the solution of the ferric hydroxide. The mechanism of this reduction process is being further studied at Lyallpur.

But the depth of the water table from the surface also influences the amount of iron held in solution, for even in percolation wells, we find that the deep wells contain more iron than do the shallow wells. Table XI, which is an abstract of Tables VI to X, shows this in a marked manner.

Table XI.

Showing the influence of depth of the well on the amount of iron in solution.

(Percolation wells only.)

Number and date of analysis	Name of town	Iron parts per million (thiocyanate method)			Control Ferrous iron parts per million by ammonium sulphide method	Description of well					
						[illegible]		Spr… [illegible]		Wa… th [illegible]	
						Ft	in	Ft	in	Ft	in
9 24-9-16	Amritsar		Absent	0.065	0.06	6	0	9	8	33	8
10 24-9-16	Do	090	Do	0.090	0.08	4	10	8	8	28	1
1 19-9-16	Ambala	0.130	Do	0.130	0.12	8	9	61	9	10	2
2 19-9-16	Do	0.060	Do	0.060	0.06	6	9	35	6	41	0
25 11-10-16	Lahore	0.078	Do	0.078	0.08	5	0	47	1	5	6
26 11-10-16	Do	0.062	Do	0.062	0.06	11	6	14	6	14	1
31 13-10-16	Sialkot	0.098	Do	0.098	0.11	5	0	54	0	8	6
32 13-10-16	Do	0.090	Do	0.090	0.10	6	0	19	0	10	0

The influence of depth of water on the amount of iron held in solution is even more marked if we compare the ratio between adjacent tube and percolation wells. (See Table XII.)

Table XII.

Showing the comparative amount of iron in solution in adjacent tube-well water and percolation well water.

Tube-well water						Percolation well water					
Number and date of analysis	Description of sample	Iron parts per million (thiocyanate method)			*Control* Ferrous iron parts per million (ammonium sulphide method)	Number and date of analysis	Description of sample	Iron parts per million (thiocyanate method)			*Control* Ferrous iron parts per million (ammonium sulphide method)
		Total	Ferric	Ferrous				Total	Ferric	Ferrous	
5 21-9-16	Ambala, tube-well No. 10	0·640	0·33	0·310	0·310	6 21-9-16	Ambala, percolation	0·10	Absent	0·10	0·10
15 25-9-16	Amritsar, tube-well No. 28 .	0·170	Absent	0·170	0·175	13 25-9-16	Amritsar, percolation well No. 1 of Delhi line	0·07	Do.	0·07	0·07
17 28-9-16	Lahore, tube-well No. 15 .	0·135	Do.	0·135	0·135	19 28-9-16	Lahore, percolation well No. 2	0·07	Do.	0·07	0·07

Table XIII.

Showing the amount of iron in the tube-wells before and after the summer monsoon.

[Before M]onsoon rains						After monsoon rains					
Number and date of sample	Description of sample	Iron parts per million (thiocyanate method) Total	Ferric	Ferrous	*Control* Ferrous iron parts per million (ammonium sulphide method)	Number and date of sample	Description of sample	Iron parts per million (thiocyanate method) Total	Ferric	Ferrous	*Control* Ferrous iron parts per million (ammonium sulphide method)
2 6-4-16	Brownlie tube-well, Dera Ghazi Khan	1·060	nil	1·060	1·12	33 29-10-16	Same, Dera Ghazi Khan ..	0·825	nil	0·825	0·830
3 8-4-16	Discharge from mains after leaving the pumps, Sialkot ..	0·840	0·36	0·480	0·480	28 11-10-16	Same, Sialkot ..	0·61	0·30	0·310	0·315
12-4-16	Well (pure percolation) Headworks, Amritsar ..	0·091	nil	0·091	0·100	13 25-9-16	Same, Amritsar	0·070	nil	0·070	0·070
12-4-16	Combined tube and percolation well, Headworks, Amritsar	0·210	nil	0·210	0·240	11 25-9-16	Same, Amritsar	0·265	nil	0·265	0·250
12-4-16	Pure tube-well Headworks, Amritsar	0·205	nil	0·205	0·203	15 25-9-16	Same Amritsar	0·170	nil	0·170	0·175

The gradual increase in the amount of ferrous iron held in solution in soil water with increasing depth from the surface or distance from the Himalayas is of interest, not only to the water engineer but to the geologist as well. The iron so held can only remain in solution so long as the water contains no dissolved oxygen, for as soon as oxygen begins to replace the carbon dioxide the ferrous salt will be oxidized and deposited as a hydrated oxide of iron. This explains the freedom from dissolved iron of the water of the larger oceans, and its presence in those seas adjacent to a

low-lying coast through which sub-soil water must certainly percolate. (*Cf.* Table XIV.)

TABLE XIV.

Showing the iron contents of sea water in parts per million (from Thorpe's Dictionary of Chemistry).

Sea	Point of collection of sample	Fe parts per million	CO_2 parts per million	Authors
Atlantic Ocean ..	0° 47′S.—33 20′W	nil	nil	Bibra Annalen 77, 90.
Do. ..	20° 54′N.—40° 44′W.			
Do ..	41° 18′N.—36 28′W			
Do ..	Cape Horn .			
North Sea ..	Between Belgium and England ..	nil	nil	Bischof, C Géolog , 1, 99
Straits of Dover..	Some miles from Havre ..	Traces	78 0	Figuier et Mialhe, J, Pharm III, 13, 406
Mediterranean ..	Marseilles ..	nil	142·0	Laurent, J, Pharm , 21 93, n, 92, 172
Do. ..	At 3,500 metres from the coast of Cette	2·8	67 9	Usiglio, Ann Chim , Phys
Do ..	The Lagunes of Venice ..	nil	nil	Calamai, 18, 47.
Pacific Ocean ..	3 5 metres below the surface ..	nil	nil	Bibra, *loc cit*
Do. ..	140 metres below the surface ..	nil	nil	
Baltic ..	....	nil	nil	Pfaff., Schweigger's Journ 22, 271.
Black Sea ..	Coast south of the Crimea ..	127·1	247 5	Göbel, P Suppl., 1, 187.
Sea of Azof ..	Between Kertch and Mariapol ..	35·8	60·5	
Caspian Sea ..	S. W of Pischnoi ..	40 1	77·3	
Dead Sea ..	....	Traces	Traces	Terreil, Compt rend 62 1329 (Wurtz, Diction naire de Chimie).

It is reasonable to suppose that at such points deposits of *limonite* will be formed and may explain the formation of beds of this substance as well as the highly ferruginous nature of some clays.

IV. THE PRESENCE OF IRON BACTERIA IN PUNJAB WELL WATERS AND THEIR SIGNIFICANCE.

A very comprehensive account of the iron bacteria will be found in a paper by Ellis, *loc. cit.* Of the various bacteria described by Ellis we have identified the following in the Punjab well waters:—

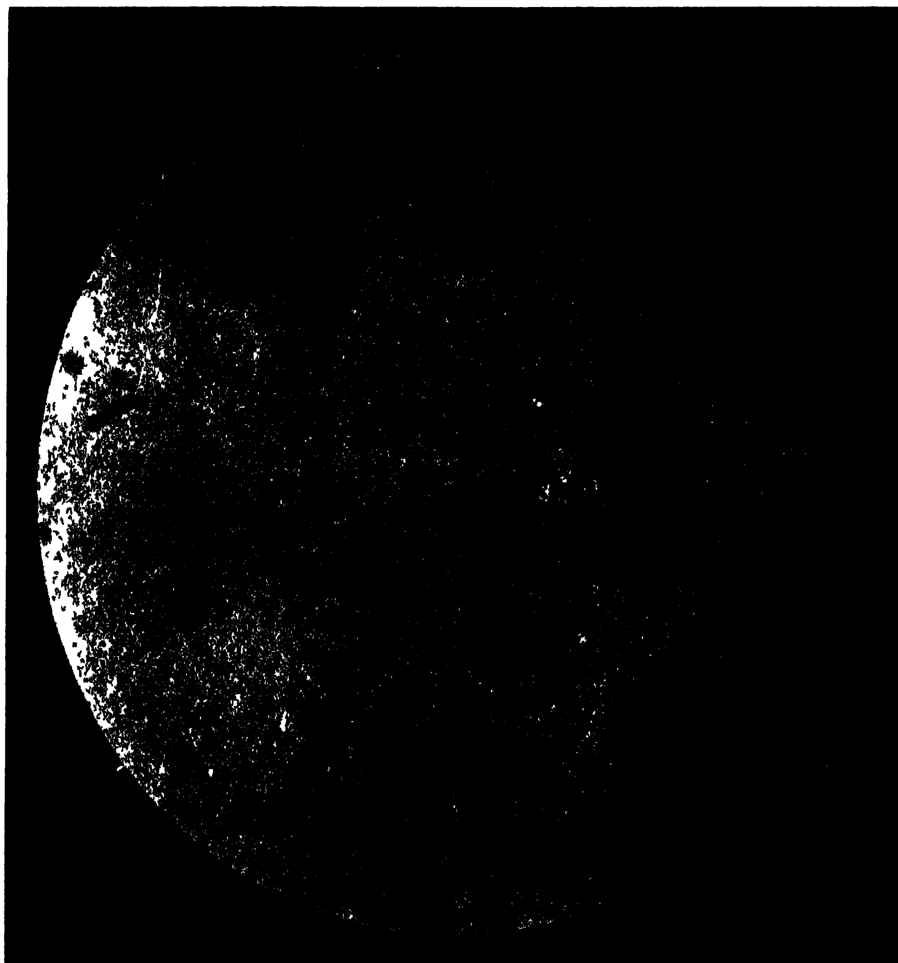
1. *Leptothrix ochracea*, syn. *Chlamydothrix ochracea* (Kutzing).
2. *Gallionella ferruginea* (Ehrenberg).
3. *Spirophyllum ferrugineum* (Ellis).
4. *Crenothrix polyspora* (Cohn).

(*See* Plates III, IV & V and Table XV.)

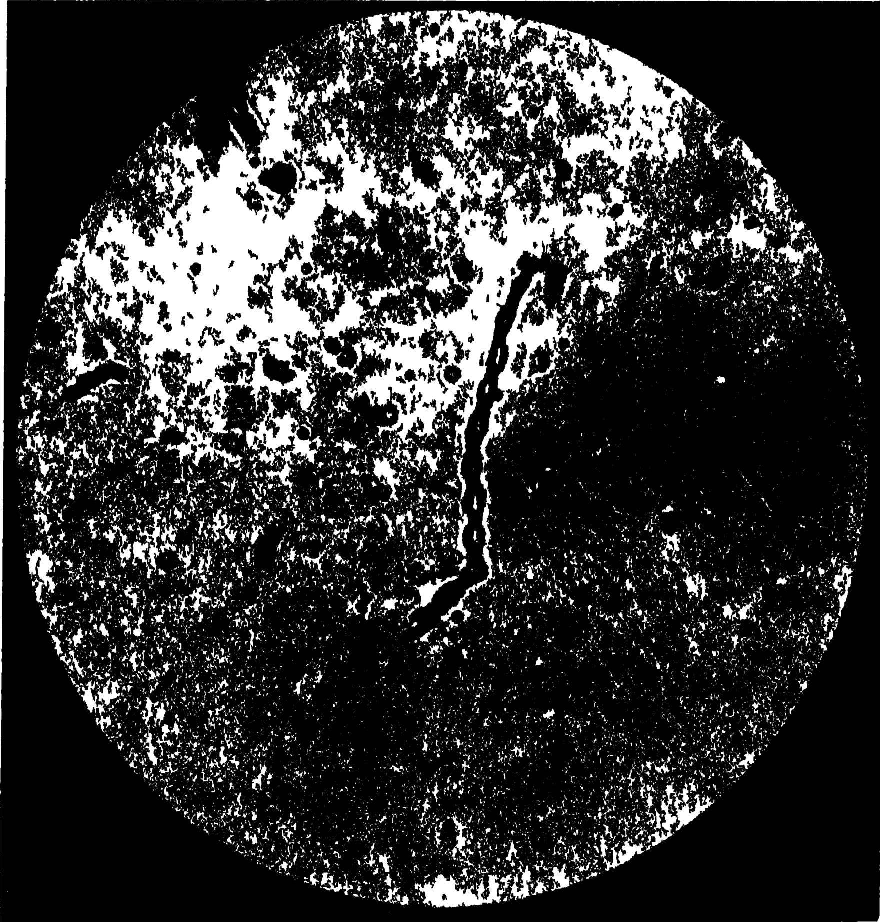
TABLE XV.

Showing the analyses of Punjab well waters containing iron bacteria.

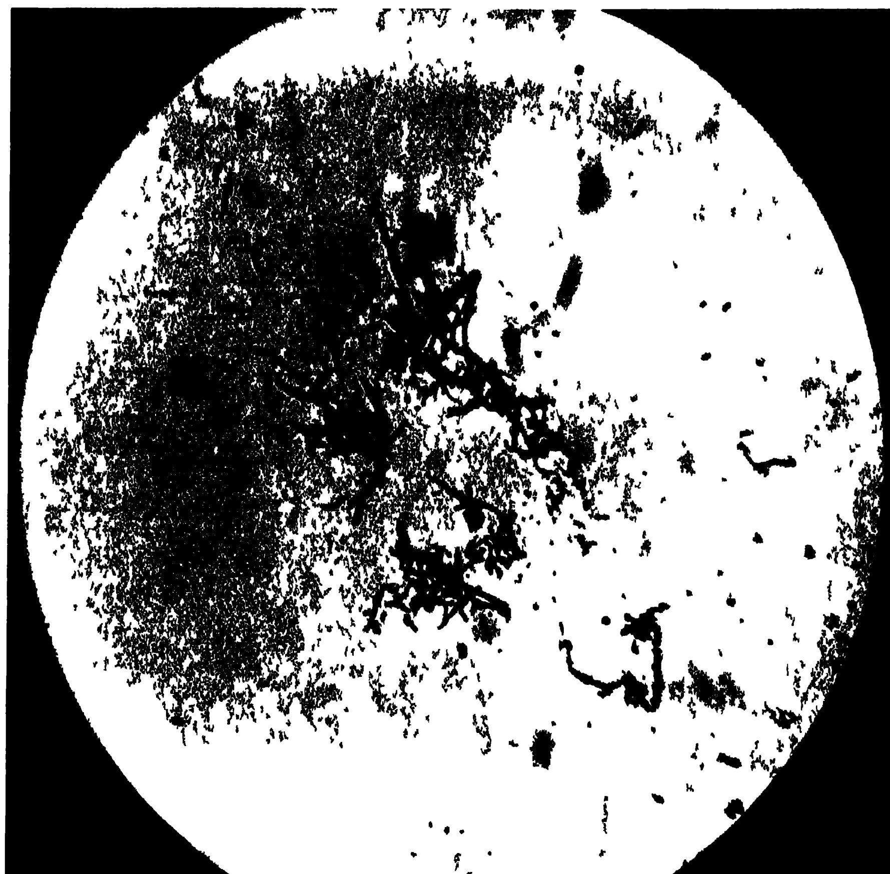
Number and date of analysis	Description of samples	Iron parts per million			Ferrous iron parts per million (check)	REMARKS
		Total	Ferric	Ferrous		
3 19-9-16	Ambala city reservoir iron tank	0·730	0·430	0·30	0·30	*Leptothrix ochracea* (very numerous)
21-9-16	Ambala, combined tube and percolation well No 1, at waterworks	·060	·0·770	0·29	0·29	*Leptothrix ochracea*
19 28-9-16	Lahore, very old, shallow but wide percolation well, Badami bagh waterworks ..	0·165	0·165	Absent	Absent	*Leptothrix ochracea* (fairly numerous)
35 30-10-16	Dera Ghazi Khan, city reservoir near Courts iron tank	0·680	0·180	0·50	0·50	(1) *Leptothrix ochracea* (2) *Gallionella ferruginea* (3) *Spirophyllum ferrugineum*



LEPTOTHRIX OCHRACEA.



GALLIONELLA FERRUGINEA



IRON BACTERIA PRESENT IN THE DERA GHAZI KHAN WATER SUPPLY

(1) LEPTOTHRIX OCHRACEA

(2) GALLIONELLA FERRUGINEA

(3) SPIROPHYLLUM FERRUGINEUM

These organisms were only found in reservoirs or standing water. In no case could they be identified in water as it issues from the pumps, and we conclude that the iron bacteria are not present in the sub-soil water when this is situated some distance from the surface. This is very clear in Table XV.

The iron bacteria are apparently common to surface water, and though it has been proved that iron compounds are not in themselves necessary for their growth and that manganese can be substituted for iron in a suitable culture media, nevertheless their multiplication in water containing ferrous iron seems at times to be extremely rapid. *Crenothrix*, which has so far only been identified in the Punjab in the Dera Ghazi Khan water, is known in Germany as the *Brunnenpest* and its activities appear sporadic and not regular. Ellis says :—

"Among its visitations may be mentioned Breslau in 1870, "Berlin in 1878, Lille in 1882, Rotterdam in 1888, and Cheltenham "in 1896. At Cheltenham in 1896 the water supplied to the town "became red and turbid and from it there emanated an offensive "odour. Within a fortnight the filters had become [illegible]. This "state of affairs continued for about six weeks after [illegible] the water "once more began to assume its normal appearance."

Though no chemical data are given in the above reports of these outbreaks we may infer that at the time they occurred the water-supply was in a particularly suitable condition for the growth of the iron bacteria. It is certain from the results of the outbreak that they were ferruginous and from the figures obtained in the Punjab in 1916 it is very evident that the iron content of the water from a single well may vary considerably with the rise and fall of the water table level. According to Ellis the more organic matter there is in solution in ferruginous water the more iron these waters are able to hold in solution. This increase might follow on sewage pollution or as the result of an abnormally wet season.

Such variations as these then might account for the sporadic nature of the outbreaks of this pest.

It appears from the results above given in the analyses of the Punjab waters that the iron bacteria begin to make their appearance

about the time the ferrous iron is changing to ferric, but there is no further evidence that Winogradski's theory is correct, *viz.*, that oxidation of ferrous to ferric compounds is the souice of energy necessary for the successful development of these bacteria.

We have had one clear case of a Punjab water-supply deiived from tube-wells (Dera Ghazi Khan, 1915) in which the water has become turbid from a deposit of ferric hydroxide. In this water we have identified some of the iron bacteria. The enquiry has shown that practically all the sub-soil water in the Punjab which is available from deep wells is sufficiently impregnated with ferrous salts to constitute their forming a suitable medium for the growth of the iron bacteria. We feel justified therefore in sounding a note of warning against the extended use of such water for municipal purposes without taking adequate precaution to safeguard the supply, and invite water engineers to take into consideration the desirability of including deferrizating machinery whenever using such water for municipal purposes and where the water has to be passed through an extensive pipe system. The presence of iron is probably of even greater importance when the water is to be used for certain industries. This is particularly the case in the textile industries—probably one of the coming industries of North India. In the bleaching and dyeing of cotton the presence of iron, even in very small quantities, is highly deleterious as it gives rise to stains on the bleached material and causes spots and modification in the shade of the dyed goods.

For the same reason the use of ferruginous water in paper manufacture is highly objectionable.

The principles of deferrization are simple. When the iron is present in the form of a ferrous salt as it is in the Punjab well waters, aeration followed by filtration suffices to remove the excess of iron. The aeration can be effected by spraying if water does not contain too much carbon dioxide or too much iron. This is usually sufficient to remove the carbon dioxide from solution and bring about the oxidation of the ferrous carbonate and its precipitation as a hydrated oxide and would probably be effective in the case of all the waters whose examination is noted above.

Chemical methods of agglutination have been used, such as the treatment of the water with sulphate of alumina, ferric chloride, etc., combined with precipitation of the carbon dioxide by milk of lime, but experience of these methods in Germany has not always been satisfactory and has in some cases led to deterioration of the water for industrial purposes.

The methods of aeration vary—in Leipzig, the raw water is made to dissolve atmospheric oxygen at a pressure of 4 to 5 atmosphere in a special chamber after which it is further exposed to the air in a conduit 2 miles long.

Cascading, spraying, distribution and circulation are among the other plans of arriving at the oxidation desired.

Intense aeration and subsequent filtration at Amsterdam reduces the iron from 0·8 part per million to nil. At Freeport, Illinois, lime is added to the raw water which is then carried to a Jewell plant, very little iron remains—never sufficient to permit of the reappearance of *Crenothrix*. Before this practice was adopted the service water was at times almost unusable.

In England filtration through *oxidium* or *polarite* yields an iron-free filtrate.

In America (*Proc. Amer. Soc. of Civil Engineers*, vol. XXXIV, pages 1324-1393, 1908) good results have been obtained on ferro-manganese waters by passing the raw water through rotating cylinders fitted with iron filings or coke impregnated with iron. A similar system using a tower of coke is in operation at Charlottenborg and Salbach. Treatment with clay followed by sulphate of alumina has given good results at Reading, U. S. A., in dealing with ferro-manganese impregnated waters from a moorland source (Don and Chisholm).

After the precipitation of the iron has been effected it will be necessary to remove the precipitate by filtration.

This may in some cases be accomplished by ordinary sand filtration by gravitation as is commonly practised in this country. We are not in favour of this method of filtration under the working conditions which exist in the plains in North India. For upwards of a year we have had the bacterial efficiency of sand filtration at

Lyallpur under observation and find that it cannot be depended upon—especially at the change of the season in the spring and autumn when the growth of the surface film necessitates frequent cleaning and the wide variation in day and night temperatures appears to disturb the sand bed. The results of these enquiries are to be published shortly and recommendations will be made to substitute mechanical filters for the present system and at the same time to increase the size of the sedimentation reservoirs as the municipal supply is in this case derived from the Lower Chenab Canal.

The Candy filter appears to be the most suitable filter for all purposes in North India. It has a long life, its maintenance cost is low, and the percentage of water required for washing is lower than any other mechanical filter (½ per cent. as against 1 to 3 per cent. in other mechanical filters) and no precipitant is needed. Oxidation is effected by the use of a layer of *oxidium*, a catalytic oxidizer which is a porous compound of iron oxide, silica, lime, magnesia, etc. Its chemical composition according to Don and Chisholm is :—

	Per cent.
Silicates of alumina, magnesia and lime ..	84·1
Iron oxide	11·0
Other alkalies and carbon	4·7
Loss on ignition	0·2
	100·0

The renewal of the oxygen necessary for oxidation is effected by an aerating chamber in the filter.

This filter has been successfully used to remove iron both in suspension and in solution at Hastings, where the water is very highly ferruginous and where open sand filtration is troublesome and expensive.

The bacterial efficiency of this filter, too, is satisfactory, and though this is not so important in dealing with tube-well water as it is in the purification of river or surface water, it constitutes an additional safeguard to the health of the public.

THE AGRICULTURAL DEVELOPMENT OF NORTH-WEST INDIA.

BY

ALBERT HOWARD, C.I.E., M.A.,
Imperial Economic Botanist, Pusa,

AND

GABRIELLE L. C. HOWARD, M.A.,
Second Imperial Economic Botanist, Pusa.

I. INTRODUCTION.

THE development of the agriculture of North-West India is largely a question of the conquest of an alluvial desert by means of irrigation. The deep soils of this region are practically inexhaustible and there is no such thing as a barren and intractable sub-soil with which to deal. Long experience in these tracts has shown that where the water-supply is adequate, the land will bear cropping for an indefinite period. There are only two defects to consider as far as the soil itself is concerned—want of organic matter and a tendency towards the accumulation of alkali salts. These shortcomings, however, are small matters compared with the want of moisture.

That water is the limiting factor in the agricultural production of North-West India is generally recognized. It has long been realized by the Government of India. The continuous development of the work of the Irrigation Department is the outward and visible sign that the State is dealing with one of the greatest problems in Indian agriculture in a practical manner. Given a supply of

water for these desert soils, the next step is to discover how it can be employed to the best advantage to the country as a whole, and how we can extract from each irrigation unit its utmost duty. That irrigation to be effective must be regarded from these two points of view is, however, not always recognized. It is often thought that the provision of water (an engineering question and the business of the engineer) is the whole of the matter. The discovery of the best method of using the water (the work of the Agricultural Department) is, however, as important to India as the construction of canals.

The position of irrigation in North-West India at the present time is this: Government has provided the people with a magnificent system of canals by which production has been increased and by which large areas of the country have been protected from famine. The people, however, do not know how to use this priceless gift to advantage and they are making all kinds of mistakes in irrigation practice and are doing an increasing amount of damage to the country. They are using far too much water on the area cultivated with the result that large tracts which might easily be made into a garden remain desert for want of irrigation. The people have yet to learn that while water is a good thing for crops over-watering on an alluvial soil leads to low yields of poor quality, to accumulations of salts and to the destruction of the porosity of the sub-soil. The State is also losing both directly in the amount of revenue collected and also indirectly in restricted opportunities for the formation of new canal colonies. To put these matters right is perhaps the greatest of the many opportunities now before the Indian Agricultural Department.

The waste of valuable water is not the only defect in agricultural practice in North-West India. The necessity of increasing the supply of organic matter in desert soils is often lost sight of and insufficient use is made of the nitrogen collecting leguminous crops. The object of this paper is to suggest a means by which the fertility of the soil in this region can be increased and by which the present supplies of irrigation water can be made to go much further.

II. The Place of Leguminous Crops in Desert Agriculture.

The obvious method of increasing and maintaining the amount of organic matter in the soil is by means of green-manuring. In desert agriculture, this is, however, a counsel of perfection, as in such areas the cultivator is not likely to expend the water and labour necessary to grow green manure and to bring about its decay in such a manner that the next crop derives the maximum advantage from the process. The problem is to discover a method by which the organic content of these desert soils can be increased which will, at the same time, prove profitable to the cultivator. It is suggested that the solution will be found in the extended growth of leguminous fodder crops like *shaftal* (*Trifolium resupinatum*), lucerne, berseem (*T. alexandrinum*), *senji* (*Melilotus indica* and *M. alba*) and *guár* (*Cyamopsis psoralioides*, DC.) which are now largely grown for green fodder round the towns and large villages of North-West India. In the districts themselves, however, the area under these fodder-crops falls off as there is little sale for the produce in the green state and no proper methods of drying and storage exist. What the country needs is a method of drying and baling these fodders and also a market for the dried produce. Once this is provided, the cultivation of these fodder-crops will develop rapidly and the ryot will then be provided with a profitable means of increasing and maintaining the organic matter in the soil. Although these fodder-crops will be reaped, they leave behind a large amount of organic residue in the soil in the shape of roots and nodules, and, as is well known, their cultivation involves the fixation of large amounts of atmospheric nitrogen.

The extended growth of leguminous fodder-crops solves another problem besides that of the supply of organic matter to the soil. Indian agriculture, as is well known, rests on the efficiency of the ox which is exceedingly low on account of a chronic shortage of nutritious food. The cattle engaged on the land and in transport on the roads are largely fed with substances of low feeding value like *bhusa*, *juâr* and maize stalks and with the miscellaneous chaff of the threshing floors. The amount of grain given to work-cattle

is small as this substance is needed by the cultivator for food and as a source of income. The weak point in the cattle ration of India is the disproportion of albuminoids to carbohydrates or, as it is expressed in works on foods and feeding, the low albuminoid ratio. Efficient and rapid work is not possible for any length of time if the albuminoid ratio falls much below 1 : 7. As it is quite the exception to find an Indian ox provided with fodder with a ratio approaching this minimum limit, it is easy to understand that the slowness and low efficiency of this animal to a large extent is a natural result of poor feeding.

To obtain better and faster work, the albuminoids in the food must be increased. It is of little use altering the breed as no working animal has yet been discovered which can do the maximum work on a food of the nature of wheat *bhusa*, the albuminoid ratio of which is not more than one to thirteen. This defect in the feeding of animals in North-West India can, to a considerable extent, be made up without the use of grain by means of properly dried and stored leguminous fodder-crops—*shaftal*, lucerne, berseem or *senji*. Analyses of these dried fodders disclose an exceedingly high albuminoid ratio[1] ranging from 1 : 3 to 1 : 4. Actual feeding trials in the Army at Quetta prove that working animals like horses and mules thrive on comparatively small quantities of such fodder. A mixture of from one to two parts of *bhusa* to one part of baled *shaftal* or lucerne provides a well-balanced ration to which the addition of grain is unnecessary except perhaps for heavy work.

Drying and baling. In the upland frontier valleys like that of Quetta, the most suitable leguminous fodders for enriching the soil are Persian clover (*shaftal*) and lucerne. Both these crops can be made into excellent hay in the arid climate of Baluchistan provided the operations of drying are carried out with care. The main difficulty to be overcome is the excessive dryness of the air and the rapid rate at which the cut fodder passes into a brittle condition.

[1] The albuminoid ratio is best expressed as the ratio of *digestible* albuminoids to *digestible* carbohydrates. As the digestion data of Indian fodders, when consumed by Indian animals, have not yet been determined, it is not possible to adopt the more accurate method. In this paper, therefore, albuminoid ratios have been calculated from the analyses.

The later stages of hay-making have to be carried out in bulk and the fodder must be collected in heaps at an early period to prevent breakage of the leaves in which most of the valuable albuminoids are found. *Shaftal* dries much more slowly than lucerne and is therefore the more easily made into hay. The beginner should not attempt the drying of lucerne till he has mastered the details in the case of Persian clover.

The preparation of baled leguminous fodders is a matter which involves the expenditure of some capital and is therefore beyond the means of the ordinary cultivator. The process can most advantageously be carried out at rural centres where ample supplies of green fodder can be produced and where there is no great competition for the available supplies such as always exists in large towns and military cantonments. The needs of the urban population for green fodder in North-West India are already considerable and the demand which now exists does not leave any great surplus for drying and baling. To obtain the maximum advantage to the land and to give the dryer and baler a fair profit, it would appear that the balance of advantage is to be obtained by the formation of drying and baling centres at some little distance from the large centres of population. In a tract like the Quetta valley for example, a considerable area of the country-side, within a six-mile radius of the Cantonments, is taken up with the growth of green fodder for the Army and the town. To set up a drying and baling station for profit at Quetta itself would merely add another competitor for the existing produce and might easily raise the price. A few miles out of the town, however, the conditions are quite different and here the establishment of baling stations would be sure to lead to the extension of *shaftal* and lucerne cultivation for drying purposes only. The preparation of the bales would appear to be best done either by the large zamindars or by contractors who could purchase the green fodder from the cultivators and dry and bale it themselves.

Feeding value. Once the difficulties of hay-making in the North-West are overcome, the resulting fodder stands in a class by itself as far as India is concerned. The *shaftal* and lucerne hay prepared at the Fruit Experiment Station, Quetta, are equal to the

very best grades of these fodders made in Europe. The composition of these two foods was determined with the following results :—

TABLE I.

Composition of shaftal and lucerne hay at Quetta.[1]

	Shaftal (in bales)	Lucerne (in bales)
Moisture	15·86	3·14
Oil	2·19	3·32
Albuminoids	14·10	15·48
Soluble carbohydrates	39·98	46·30
Woody fibre	13·80	17·70
Soluble mineral matter	12·88	11·83
Sand	1·19	2·23
TOTAL	100·00	100·00
Total nitrogen	2·48	2·98
Albuminoid nitrogen	2·26	2·48
Albuminoid ratio	1 : 3·2	1 : 3·5

Up to the present, two series of tests with baled *shaftal* have been carried out at Quetta. In 1915, a series of trials were made on the horses of the 72nd Heavy Battery, R.G.A., the results of which were very promising. In this test, a chop composed of three parts of *bhusa* to one part of dried *shaftal* proved an excellent feed and the horses throve really well on it and the *shaftal* made the shyest feeders eat *bhusa* freely.

In 1916, a more extended trial was carried out under the direction of Brigadier-General Cook, R.G.A., on one of the mule teams of the 4th Mountain Battery where the animals were fed on dried *shaftal* only. The results were very promising; the animals improved in condition, and the trials clearly indicated that by the use of dried leguminous fodders a very considerable saving in the weight of fodder used on active service could be obtained. The results of these trials have been submitted to Army Headquarters at Simla, and it has been decided to carry out during 1917 extensive trials on many of the units of the Quetta Division. The Army has agreed to purchase 6,000 maunds of baled *shaftal* in 1917 for the

[1] These analyses were carried out at Pusa by Mr. J. Sen, Officiating Imperial Agricultural Chemist.

purpose of these experiments and arrangements have been made to grow and bale this amount near Quetta.

III. The Saving of Irrigation Water.

In order to increase the organic matter in the soil by means of leguminous crops it is evident that a good deal of water will be required. This can be obtained by the application of water-saving methods in the growth of wheat and gram, the most important cereal crops of North-West India.

Since the year 1912, a considerable amount of attention has been paid at Quetta to the discovery, under Indian conditions, of the maximum duty of water when applied to wheat. It was found that very good crops could be obtained by a single watering instead of the six or seven irrigations now given by the zamindars. This single irrigation should be applied about a week before sowing the wheat and everything should be done to conserve the moisture. This watering enables a good deep-rooting stand of wheat to be obtained and carries on the crop till the winter rains are received. These are conserved by breaking up all crusts with the lever-harrow as soon as the land is dry enough. Proceeding in this manner, the average Experiment Station yields of wheat on large areas with one watering were nearly eighteen maunds to the acre. On a cultivator's field in 1916, a still higher yield was obtained, namely, $22\frac{3}{4}$ maunds of grain and $43\frac{1}{2}$ maunds of *bhusa* per acre. These differences are due to the character of the land. The dry crop area at the Fruit Experiment Station is high-lying, light land which does not hold water very well. The typical wheat lands of the valley are distinctly heavier in texture and more moisture-retaining. The demonstration work on this subject is being rapidly extended in the Quetta valley and during the present year a large area has been sown with wheat on a single irrigation.

As far as water saving is concerned, the full significance of the Quetta results can only be realized if the duty of water as used at the Experiment Station and by the zamindars is compared. The average yield on large scale trials on unmanured land at the Experiment Station worked out at $17\frac{3}{4}$ maunds of wheat per acre for one

irrigation. The zamindars often water their wheat seven times and obtain an average of $13\frac{1}{2}$ maunds of grain. The same amount of water spread over 7 acres, if used according to the method employed at the Experiment Station, would give 7 times $17\frac{3}{4}$ or $124\frac{1}{4}$ maunds of wheat. The difference in the duty of water is therefore $110\frac{3}{4}$ maunds of wheat per acre. If the average irrigated acreage of wheat in the Quetta valley is multiplied by 100, the result would indicate in maunds of wheat per annum, the present annual waste of water on this crop alone. On every 200 acres of irrigated wheat, the water now lost would produce 20,000 maunds of grain and a large amount of straw of a total value not far short of a lakh of rupees. It is probable that other crops besides wheat can be grown on much less water than is now employed. As is well known, gram is a crop which does not thrive under irrigation on soils like those of the Chenab Colony. The growth is often luxuriant but the yield of seed is disappointing. It is more than probable that good crops of gram could be raised on a single watering, applied just before sowing, as has been done in the case of wheat in Baluchistan.

In the saving of water, a great deal can be done in addition to the proper cultivation of the land itself. At Quetta, the use of properly aligned field channels of the right size, provided with strong turfed berms, enables the water to be controlled with very little trouble and also makes it go further. If the size of the field *kiaris* is carefully adjusted to the volume of water and if they are carefully graded so that the flow is even and all parts are equally watered, still further saving results. The advantages of the long oblong *kiari* with a slope of about one inch in 100 feet watered from one end will become more obvious as time goes on. All these irrigation improvements are simple ones and can be carried out with the labour, cattle and implements now available in India.

IV. Summary.

The object of this paper is to draw attention to the problems underlying the development of agriculture in North-West India. It is suggested that the question must be regarded simultaneously

from two points of view—the enrichment of the soil by the extended growth of nitrogen collecting leguminous plants and the saving of irrigation-water.

No great extension of the leguminous fodder crops of this tract is possible unless they can be dried and baled and unless the product can be sold to advantage. To introduce this fodder to the notice of all concerned, there must be a steady demand and for this purpose the Army is the most obvious purchaser. On this account, the trials of baled *shaftal* by the Quetta garrison were initiated and developed. The tests already made show that by the use of such fodders the weight of forage taken by an army on active service can be reduced by 25 to 30 per cent., an obvious military advantage. The extended growth of these fodders will enrich the land and will increase the production of crops like wheat. A great opportunity for developing the North-West now presents itself in which the Army authorities and the Government can work together to the mutual advantage of both. In such a matter, the Army will not function as a mere spending Department but as a powerful agent of development in that region of India in which it is mainly concentrated.

Once the Army comes into the market for these dried fodders, their extended use is certain. Any one who has seen the poor feeding of the thousands of cattle engaged in moving produce over the main trunk roads in the North-West will at once realize how much these fodders would improve the efficiency and reduce the numbers necessary for the work. In urban areas, both cattle and horses are underfed and overworked. The numerous dairies springing up in the large towns are producing milk inferior both in quantity and quality to that which would be possible if the albuminoid ratio of the fodder could be improved. For famine reserves, these baled fodders would be of the greatest use. Such produce is easily stored for long periods, is readily transported and the quantity is easily checked by merely counting the bales. It is highly nutritious and therefore would be a useful reinforcement to such materials as *bhusa* and dried grass whose function would be the dilution of the leguminous hay.

The water necessary for the extended growth of leguminous fodder-crops can be found by the adoption of water-saving methods such as those described in the bulletins of the Fruit Experiment Station at Quetta. In Baluchistan, the water wasted every year on every 200 acres of irrigated wheat would grow grain and *bhusa* worth a lakh of rupees. These methods or simple modifications can be applied to the Punjab, Sind and to the Western Districts of the United Provinces. Their adoption would release a large volume of irrigation water which is not only wasted but which is doing a great amount of harm to the country.

Once these improved methods become general in North-West India, the producing power of the soil is certain to increase. The work-cattle will be better fed and the door will be opened for a more intensive cultivation of the land and for the use of heavier and better implements. The country will, at the same time, support a larger population and with the increased production of the soil the prosperity of the people will rapidly improve. Indian agriculture is at present labouring in a vicious circle. The land does not produce enough to admit of the work-cattle being properly fed. Without more efficient oxen it is difficult to adopt the simplest cultural improvements. Only the surface of the soil is scratched and only the merest skin of the deep alluvial soils of the plains is made use of by crops. This vicious circle, however, can be broken. Nature in the form of the nitrogen-fixing leguminous fodder-crops provides the means. The resources of the State, properly directed, are amply sufficient to utilize this means.

THE PHOSPHATE DEPLETION OF THE SOILS OF BIHAR: ITS EFFECT ON THE QUALITY AND YIELD OF CROPS AND THE CONTINGENT RISKS OF MALNUTRITION AND ENDEMIC DISEASE IN CATTLE AND MAN

BY

WILLIAM A. DAVIS, B.Sc.,

Indigo Research Chemist to the Government of India

In a report submitted to Government on the indigo industry of Bihar, I have pointed out the abnormal deficiency in phosphates of the soils of Bihar and its effect upon the growth of indigo. In the present paper I consider the connection existing between this deficiency and the quality and yield of other crops and the increasing risks of malnutrition and disease both in cattle and man.

I. The Deficiency of Available Phosphates in the Soils of Bihar.

In 1902 Rawson pointed out in his report on indigo that many of the Bihar soils were decidedly deficient in available phosphate, and in 1907 at Pusa Dr. Leather made a series of analyses of soils from indigo factories. Some 115 soils were examined and the results, which have not yet been published, show that the amount of available phosphate, with a few rare exceptions, had fallen to values between 0·0001 and 0·01 per cent. Now in Europe it is generally accepted that a good fertile soil should contain at least 0·01 per cent. of phosphate in a soluble form so that judged by a European standard all these soils were in a dangerously exhausted condition. In January 1908 Dr. Leather in a report to the Bihar Planters' Association

expressly states :—"The chemical analyses of the soils showed them to be almost uniformly deficient in available phosphate." In spite of this warning, phosphate manuring has been resorted to in only a few isolated cases and I have come to the conclusion that the neglect of this has been the main cause of certain difficulties in indigo cultivation and the undoubted falling off in recent years which several planters have reported to me in the yield of other crops, especially cereals, on many of these estates. In the following table the results are given of the analyses made at Pusa in 1907 of a number of Bihar soils showing the abnormally low values of the available phosphate determined by the citric acid method (extraction of 100 grams of soil with 1 litre of 1 per cent. citric acid).

TABLE I.

The amount of available phosphate in Bihar indigo soils.

(C. Champaran, D. Darbhanga, M. Muzaffarpur, S. Saran.)

No.	Estate	Number of soils analysed (in 1907)	Range of available phos values per cent.
1	Mullayah, C	2	0·00018-0·00047
2	Moniarah, S	6	0·00012-0·0535 (3 soils below 0·0005)
3	Ramakola, S	9	4 soils, 0·00016- 0·00027 5 soils, 0·0025-0·007
4	Doulatpore, D	3	0·0005
5	Kurnowl, C	2	0 00025-0·0009
6	Kootoopore, M	4	0·0006-0·0065
7	Rajpore, C	3	0·00045-0·0015
8	Bhatowli, M	7	1 soil, 0·00018 6 soils, 0·00036-0·00288
9	Thikaha, M	3	0·00027-0·00045
10	Muktapore, D	3	0·00027-0·00043.
11	Pursa, C	1	0·00064
12	Harsingpore, D	1	0·00045
13	Dooriah, M	1	0·00487
14	Benipore, D	3	0·0127-0·0205
15	Bathnowa, M	3	0·00275-0·00929
16	Jogpore, S	5	0·0012-0·046
17	Sitamarhi, M	4	0·010-0·0748

It is seen from this table that in 1907 many of the fields contained less than 0·0002 per cent. of available phosphate, that is less than $\frac{1}{50}$th the amount generally regarded as necessary for fertility. In nearly all cases the amount was less than 0·0005 per cent. and it is

only in a few exceptional instances (Nos. 14, 16 and 17), that the values for available phosphate exceed 0·01 per cent. No. 17 comprising 4 soils with a range of 0·01 to 0·075 per cent. of available phosphate, are typical soils of the Bagmutti alluvium, which is well known to be exceptionally fertile as compared with other soils in Bihar.

The cause of the low values of available phosphate.

The low values for available phosphate are due to two causes. In the first place the "total" phosphate from which the "available" phosphate is derived, is abnormally low in the soils of Bihar. It is unfortunate that in 1907 at Pusa the "total" phosphate was determined in only a few cases, but the analyses made by Rawson in 1899 (Report to Indigo Defence Association 1899, and Report to Bihar Planters' Association, 1904) show that in most cases, especially in Champaran, it was very low, frequently below 0·1 per cent. The actual small proportion of total phosphate left is probably mainly responsible for the low values of available phosphate; the phosphate that remains is in a difficultly soluble form. There is, however, no doubt that the high proportion of calcium carbonate frequently amounting to 30 or 40 per cent. in the Bihar soils is also partly the cause of the abnormally low values for available phosphate. Experiments recently made at Pusa by Mr. J. N. Sen show that when calcium carbonate is added to a non-calcareous soil giving high values for available phosphate, the results obtained by the ordinary method of determining available phosphate fall off rapidly as the amount of carbonate is increased, no doubt largely owing to the neutralization of the citric acid used for extraction.

It must however be recognized that even in the case of highly calcareous soils the measurement of the available phosphate by the ordinary method gives valuable diagnostic indications of the manurial requirements of the soil. The presence of a large proportion of carbonate which interferes with the determination of available phosphate without doubt also interferes with acids of the soil (carbonic and organic acids) in their work of bringing the insoluble phosphates into a soluble condition such as is necessary to serve as plant food. Abnormally low values in such cases obtained by the citric acid

method would indicate a corresponding deficiency of soluble phosphate for the plant to utilize.

Superphosphate manuring indeed has in practice been found to give the most striking results in the case of soils in which the high proportion of calcium carbonate diminishes the rate of formation of available phosphate in the soil. This is clearly shown by the results obtained wherever experimental trials have been made in Bihar on a large scale and also in actual practice on the few estates where superphosphate manuring has been adopted.

Experimental trials.

The results obtained at Dooriah are particularly striking. In 1899 Rawson's analyses show that the Dooriah soil although the *richest in total phosphates* (0·21 per cent.) of those examined, was approaching a dangerous condition as regards *available* phosphate (0·013 per cent.). The other soils examined in 1899 were on the whole poor in total phosphates (0·08 to 0·17 per cent.) and in available phosphate (0·008 to 0·021 per cent.). In 1907 the analyses made at Pusa (see Table I) show that the Dooriah soil was still one of the richest of those tested as regards available phosphate but the amount had fallen to 0·005 per cent. which is below the ordinary standard of soil fertility.

The results of recent experimental manuring trials carried out at Dooriah (1913-14) which have been placed at my disposal by Mr. F. Mackenzie, show very clearly that an important factor limiting the growth of cereal crops at Dooriah is deficiency of phosphate and that superphosphate manuring alone gave increases of 50 to 100 per cent. with wheat and barley. (*See* Table II below.)

Manuring with sunn-hemp alone has in most cases been of little advantage. In the case of barley it had a depressing effect on the crop possibly because it had not sufficiently decomposed or due to the action of "toxins" (compare the values with mineral fertilizers but with and without hemp). In all cases the increase caused by the addition of 1 maund of super is very marked (compare plots 1 and 3 ; 5 and 7), the return being more than doubled in the case of Bissonpore barley. The addition of nitrate of soda as a rule had very little effect whilst an extra maund of superphosphate (plots 4 and 8) gave practically no further increase.

TABLE II.

Experimental results at Dooriah in 1913-14.
Yields in maunds and seers per bigha.

	GREEN-MANURED, SUNN-HEMP				NO HEMP			
Field and Crop	Plot 1 1 md. super	Plot 2 1 md. super 1 md. nitrate of soda	Plot 3 no fertilizer	Plot 4 2 mds super	Plot 5 1 md. super	Plot 6 1 md. super 1 md. nitrate of soda	Plot 7 no fertilizer	Plot 8 2 mds. super
Wheat								
Bissonporo Syriah	17·0	16 20	11·14	17·00	14·00	16 70	13 34	17·90
Lucknow ..	16·3	16·21	10·34	17·24	15·31	13·22	10·15	14·20
Barley								
Balliah ..	11·26	15·20	9·30	13·10	21·26	22 25	18 10	21·27
Bissonporo ..	29·16	28·50	14·80	30 30	28·20	30 60	12·13	29·15

Even on the Pusa Estate, which has not been stripped of its phosphate so drastically as the indigo estates of Bihar, Mr. Henderson Imperial Agriculturist, informs me that phosphate manuring alone frequently gives 50 to 100 per cent. increases of crop.

TABLE III.

Showing yields (grain) in lb. per acre in the experimental plots (Punjab Field) at Pusa in 1915-16.

Plot No.	Manure	SERIES A		SERIES B	
		(Kharif) Maize	(Rabi) Oats	(Kharif) Maize	(Rabi) Arhar
1	No manure	806	665	474	1,343
3	Farmyard manure to supply 20 lb. N.	1,415	1,053	941	1,474
4	Farmyard manure to supply 30 lb. N	1,456	1,118	1,076	1,246
5	Rape cake to supply 29 lb. N. ..	1,251	558	657	1,057
6	Sulphate of ammonia to supply 20 lb. N.	818	421	438	873
7	Sulphate of potash to supply same K_2O as in 3 ..	782	351	412	883
8	Super alone to supply same P_2O_5 as in 3	**1,201**	**1,162**	**1,151**	**940**
9	Sulphate of potash and super to supply K_2O & P_2O_5 as in 3 ..	1,117	1,033	951	924
10	Sulphate of ammonia, potash & super to supply K_2O, P_2O_5 & N, as in 3	1,119	1,006	1,213	912
11	No manure and no leguminous crop in rotation	645	400	664	309 Barley
12	Green manure in cereal rotation ..	..	579	1,031	518 Barley
16	Green manure and superphosphate to supply P_2O_5 as in 3 ..	..	**1,840**	**1,552**	**722 (Arhar)**

These results show very clearly that the principal factor limiting growth in the Pusa soil is a deficiency of phosphoric acid. The maximum results were obtained with farmyard manure, but super alone supplying the same amount of phosphoric acid gave nearly the same total results. The low results on plots 6 and 7 supplying nitrogen and potash alone without phosphate, show that the soils are deficient in phosphate and that this is the principal limiting factor. Comparison of plots 8, 9 and 10 shows that the addition of potash and sulphate of ammonia to superphosphate does not increase the yields given by super alone ; in fact there is a slight falling off.

In series A (plots 3 and 8), farmyard manure with maize has given better results (1,415 lb.) than super alone (1,201 lb.), but having lost more phosphate to the maize, it gives a smaller crop of oats than super alone (1,162 lb.). The *total* crop with farmyard manure (2,468 lb.) is nearly the same as with super alone (2,363 lb.).

In series B there is a reversal of the results in A. The maize crop with farmyard manure (941 lb.) is less than with super alone (1,151 lb.), but the *arhar* crop (leguminous) is then greater (1,474 lb.) than with super (940 lb.). The total crop is thus greater with farmyard manure (2,415 lb.) than with super (2,091 lb.), but the whole of the difference is in the *arhar*. The high yields in this case are due to other causes than the amount of N, P_2O_5 and K_2O ; a comparison of plots 8, 9 and 10 shows that the addition of nitrogen and potash to super does not increase the yield of *arhar*.

The yield of *arhar*, too, in the *unmanured* plot No. 1 (1,343 lb.) is far higher than on plots 8, 9 and 10 and nearly the same as with farmyard manure.

The enormous increases caused by adding superphosphate after green-manuring (compare plots 12 and 16) are very striking as a proof of the efficiency of such combined manuring.

The practical results obtained by phosphate manuring in Bihar.

There is no doubt that during the whole period of cultivation of indigo the Bihar soils have been steadily robbed of the small amount

of phosphoric acid originally existing in them and no attempt has been made to replace this essential constituent by the use of artificial manures (superphosphate). Under the present system indigo is grown in rotation with cereals and follows two or three crops such as maize, wheat or barley.

Generally the land is manured only with "seet," the refuse from the steeping vats, before being sown for the cereal crops. Now this seet, containing a large proportion of phosphate, taken from the soil, *only returns to it* sufficient phosphate for an indigo crop so that when indigo is grown in the rotation after the cereal there is very little phosphate left available in the soil and the plant has to make headway under adverse conditions.

Superphosphate has in the past been applied on only a few estates in Bihar, and then only for cereal crops. But in every case where it has been used, which has come to my knowledge, it has given excellent results. Thus at Dholi for several years about Rs. 16,000 per annum were spent on superphosphate and at Dalsing-sarai Rs. 10,000 per annum; the increased return in each case more than justified the expenditure. When at Dalsing-sarai, as an "economy" the manuring was cut down, Mr. F. Coventry informs me, the crops fell off in a surprising manner and phosphate was again resorted to with good results.

Perhaps the most striking results have been obtained with mustard. In 1901, the experiments made at Dalsing-sarai with this crop by the Indigo Improvement Syndicate, according to the report by Bernard Coventry, showed that the response of the soil "to the action of superphosphates is marvellous and goes to prove that not only does the crop itself require them but that the generality of lands in Bihar are deficient in phosphoric acid." In 1899, superphosphate increased the mustard crop by 800 per cent., in 1900 by 300 per cent. and in 1901 by 250 per cent. The field experiments recorded by the Indigo Improvement Syndicate (Report, 1901, p. 23), show very clearly that the addition of nitrate of soda had very little, if any, effect in increasing the crop beyond the level reached by superphosphate alone. In this respect the Dalsing-sarai results confirm the field experiments made at Pusa (see Table III), which show that

the principal limiting factor to the growth of crops in these soils is the deficiency of phosphoric acid : addition of nitrogenous or potash fertilizers, without phosphate, does not cause any appreciable increase of crops. That heavy manuring with superphosphate paid was shown at Dalsing-sarai in 1901, by the fact that the nett profit per acre was greatest (Rs. 110) on the plot where superphosphate was most heavily applied (5 cwt. to the acre) ; on the unmanured field the nett profit was only Rs. 51.

The most striking results have been obtained in practice by combining superphosphate with green manure. The Pusa and Dooriah experiments quoted on p. 81, show that green-manuring alone often produces very poor returns but if superphosphate is added the maximum result is obtained, the crop being increased threefold as compared with the unmanured plots.

It is an interesting question, how the superphosphate acts in improving crops in the Bihar soils. Phosphate deficiency may limit the crops not merely by withholding from the plant an essential constituent of growth but also by preventing the proper development of the soil bacteria for the nutrition of which a phosphatic medium is necessary. It is well known that a deficiency of phosphate in English soils first shows in the falling off in the growth of leguminous plants, such as clover and *Lotus corniculatus*, whereas manuring with phosphate alone encourages the growth of these plants at the expense of others. This is well shown in the Rothamsted grass plots. In such cases, it seems probable that the phosphate acts primarily in supplying nutrient to the bacteria of the root nodules. The same thing probably holds also in the case of indigo. The fact that green-manuring alone frequently produces poor results in India with cereals, sometimes lower than on the unmanured plots, but in combination with superphosphate gives far higher results than any other manure, would suggest that the phosphate greatly facilitates the bacterial decomposition of the green manure or helps to eliminate or neutralize toxic products of the latter which interfere with assimilation by the plant.

II. The Risk of Malnutrition and Endemic Disease due to the Impoverishment of the Soil.

The impoverishment of the soils of Bihar in phosphate as, I have pointed out in an article in the *Agricultural Journal of India,* vol. XII, pt. II, has its effect not merely on the actual yield of the crops but on their *quality.* There is little doubt, from a comparison of analyses made of the same soils during the past 20 years, that the stock of phosphate in the soils of Bihar has been steadily falling and a further diminution carries with it grave risks of malnutrition and disease due to the crops containing an insufficient amount of certain vitally essential constituents.

Certain "deficiency" diseases, such as beri-beri and polyneuritis, are generally attributed to the use as main diet of polished rice containing an insufficient supply of such substances for proper nutrition. The percentage of phosphoric acid is generally accepted as an index of the beri-beri producing power of a sample of rice. Rice containing 0·47 per cent. of phosphoric acid has been found to be a healthy food for fowls, whilst rice with only 0·28 per cent. brought about polyneuritis in a few weeks. The recent analyses of rices of Bihar by Mr. J. N. Sen (*Pusa Bulletins,* nos. 62 and 65), show that whilst a few of the polished rices examined contained from 0·4 to 0·5 per cent. of phosphoric acid, 7 out of 18 samples were dangerously near the beri-beri limit of 0·28 per cent., three samples containing less than 0·29 per cent. The sample from Sabour contained 0·27 per cent.

Now the deficiency of phosphoric acid in the rice grain is undoubtedly to be attributed to a deficiency of phosphate in the soil on which it was grown. Four out of five samples from Sabour showed very low values—0·27 to 0·33 per cent., and the Sabour soil contained only 0·11 per cent. of total phosphoric acid—a value which, however, is probably higher than would be given by many other soils in Bihar to-day. The phosphoric acid in the rice grown at Sabour was always far lower than that in a Hawaiian rice grown on a soil containing 0·48 per cent. P_2O_5.

It would perhaps be unsafe to prophesy that the continued depletion of the phosphates in the soils of Bihar will necessarily be

followed by a spread of beri-beri but there is distinct danger that this may be so. There is, however, no question that the rices of Bihar, and probably also other crops, are deficient in a vitally essential constituent. There is, too, an intimate connection between soil impoverishment and malaria. In his recent *Report on Malaria in Bengal* (pp. 64-65), Dr. C. A. Bentley points out that the fever indices are highest " in areas in which harvests have been comparatively poor and where exhaustion of the soil necessitates frequent fallows, " and that fever increases as a direct consequence of agricultural deterioration. " In Bengal, soil exhaustion and agricultural deterioration are accompanied by an increase of malarial infection." In most cases it is probable that in Bengal, where beri-beri is fairly prevalent, the exhaustion of the soil, as in Bihar, is due to a deficiency of phosphates. If this were supplied in the form of a phosphatic manure, there would be no necessity for frequent fallowings and more abundant crops would probably be obtained.

Malnutrition of cattle, low milk yield, and nervous diseases of horses associated with deficiency of phosphate.

There is, I think, no doubt that the poor quality of the cattle in Bihar and the low yield of milk is largely due to malnutrition owing to a deficiency of phosphate in the soil. It is well known that the supply of phosphate in the food has an enormous effect in increasing the yield of milk and dairy produce.

In Bihar the native buffaloes give not more than 3 seers of milk a day, sometimes rising to 5 seers, whereas in other districts, where better feeding conditions hold, the breed of cattle is far superior and the yield of milk is far greater. Thus the Jaffrabadi buffaloes in Kathiawar yield from 15 to 20 seers of milk a day, a good Delhi buffalo yields 25 seers and a Surat buffalo 16 seers or more (Mollison's *Text-book of Indian Agriculture*). That the milk yield is not merely a question of breed appears from the fact that when such high-yielding buffaloes have been introduced into Bihar their milk has rapidly fallen off, so that as a rule there has been little introduction of outside stock.

Diseases of horses. In 1880 Dr. Wallace Taylor observed that epidemics of beri-beri in man were frequently associated with outbreaks of paralysis in animals. For many years before being an agricultural research station, Pusa was run as a Government stud farm but the results obtained were not satisfactory and it was finally abandoned, the reason being, I am informed, that the horses bred on this estate were lacking in vitality and subject to nervous disorders.[1] There is no doubt that such forms of paralysis in horses as *kumri* are specially prevalent in Bengal and Bihar (see Hay's *Veterinary Notes*, 1903, p. 543) and as pointed out by Meyrick (*Horses in India*, p. 63), *kumri* was very common amongst the Government brood mares at Buxar, where one of the late Bengal studs was situated. This disease has all the characteristics of a deficiency disease such as beri-beri. It usually comes on gradually and sometimes a horse will remain only slightly affected for weeks or years. Treatment is useless in most cases but according to Burke (*Tropical Diseases of the Horse*, p. 58), change of situation always brings about an improvement. There is, therefore, a close parallelism with beri-beri and it seems highly probable that, just as in the latter case, phosphate deficiency is the cause. It is highly significant that in certain provinces such as the Punjab or North-Western Provinces where the soils are more phosphatic[2] both diseases are rare and that in Bengal and Bihar, where it is known the soils are deficient in phosphate, the greatest number of cases come on towards the close of the rains (Burke, *loc. cit.*). It is at the same period that indigo "wilt" appears, a fact which I have explained as due to the washing out of the soil of the small reserves of available phosphates. At this period of the year the herbage would contain its minimum of phosphate, so that phosphate starvation would be most accentuated.

1 For this and other information regarding the cattle and horses in Bihar, I am indebted to Mr. Judah Hyam, Veterinary Overseer, Pusa.

2 Analyses of a few Punjab soils are given by Leather (*Agricultural Ledger*, 1898, no. 24) in his collection of Indian soils. In all cases the available phosphate is high, in some cases unusually so. Some of the North-Western Province soils contain from 0·4 to 0·5 per cent. of total phosphate of which more than half is "available."

III. The Possible Deficiency of other Essential Plant Food Constituents in the Soils of Bihar.

The striking results obtained with mustard at Dalsing-sarai by manuring with superphosphate have been already referred to (p. 83). In previous years the mustard crop has been increased three-to eight-fold by such treatment. This year (1916), mustard was sown in October in many fields at Dalsing-sarai as a cover crop with indigo, a portion of the field being manured with superphosphate, the rest remaining untreated. In every case where no superphosphate was applied, the mustard has almost died out, whereas on the same fields treated with phosphate there is already (December) an abundant crop.

In the practical manuring of indigo with superphosphate, to obtain the best results most economically, it will be necessary to ascertain which fields specially need the application of phosphate. As the analyses given in Table I show (see specially No. 2, Monariah) it frequently happens that on the same estate some of the fields are comparatively rich in phosphate whilst others are totally deficient. To economize manure a simple method of ascertaining which fields require superphosphate needs devising—it is obviously impossible to find this out by actual analysis of each individual field. Now if the striking results obtained with mustard are due to the phosphate alone, this crop would be a very sensitive means of revealing phosphate deficiency. It would only be necessary to grow mustard as a cover crop with indigo and observe the character of the crop. If the winter mustard crop is poor, phosphate deficiency is indicated and could be made good for the indigo by a top-dressing before the rains.

It is however possible that part of the stimulating effect of superphosphate on mustard is due to the large quantity of calcium sulphate contained in this manure. Several analyses which I have made of Bihar soils show that these are deficient not only in *phosphoric acid* but also abnormally so in *sulphates*.

A deficiency of sulphate is seldom met with in agricultural practice so that one rarely has to concern oneself with making good such deficiency by manuring. But the mustard plant specially needs

sulphur for its metabolism—the mustard seed contains 1 to 1·5 per cent. of sulphur, and the mustard oils and glucosides (*sinalbin* and *sinigrin*) are complex sulphur compounds. So that it is probable that, in the case of mustard, a limiting factor to growth in the Bihar soils may be sulphur as well as phosphate. Whether this is so can only be ascertained by direct experiment and I intend to make practical trials by manuring with gypsum to elucidate this.

Dr. E. J. Butler has drawn my attention to the striking results obtained this year by Mr. A. C. Dobbs, Deputy Director of Agriculture, Chota Nagpur, at the Ranchi Government Farm. The soils of Chota Nagpur are apparently remarkably deficient in sulphate, containing traces only of sulphuric acid. They contain also a very small amount of phosphoric acid and lime. According to Mr. Dobbs,[1] the yields from these soils under ordinary conditions are very poor, whilst the application of a "very small amount of sulphur has had a most remarkable effect on the groundnut." With such soils superphosphate would give probably the maximum results, because this manure contains all those constituents, phosphoric acid, sulphuric acid, and lime of which they stand in need.

[1] See "Agricultural Experiments in Chota Nagpur." In a paper read before the Third Indian Science Congress, 1916, reprinted in a special number of this *Journal*, Mr. Dobbs states (page 42)," the very remarkable effects of small quantities (10 to 40 lb. per acre) of sulphur and of gypsum on groundnuts indicate that sulphur may sometimes be a limiting factor," and again (page 45) "the effect of sulphur was quite phenomenal and would have needed no duplication of plots for its detection even when only 10 lb. per acre was applied."

CONDITIONS INFLUENCING THE DISTRIBUTION OF POTATO BLIGHT IN INDIA.

BY

JEHANGIR FARDUNJI DASTUR, B.Sc.,

First Assistant to the Imperial Mycologist.

THE fungus *Phytophthora infestans*, though perhaps present in Southern Germany and the Rhine valley between 1830 and 1840, did not become generally known till 1845, when it developed into an epidemic which swept through every potato-growing district from Russia westward to Canada; since then this disease has not been completely eradicated from these affected areas. It has now been introduced practically all over the potato-growing countries along with the import of seed tubers from infected tracts, but has remained confined to certain localities because it thrives best at low temperatures. Jensen has shown that the fungus cannot exist where the mean temperature exceeds 25°C. or 77°F. Therefore, in Europe it is chiefly found north of latitude 50°; and in America it is common in the northern States, especially northern New England and New York and also in adjacent Canada, but further south and west it is either unknown or more sporadic. In fact in the United States it is seldom found south of latitude 40°. Nevertheless in latitude 37° Reed has found it attacking potatoes at the altitude of Blacksburg, Virginia (2,200 feet). According to him the disease in this State is practically unknown below 2,000 feet. Thus the presence of this fungus in a region south of the usual tract where it is ordinarily found, shows that a higher altitude compensates for the difference in latitude. That this disease, if introduced, will

develop anywhere under favourable local conditions (moist weather without too great heat), is seen from the fact that it is reported from Equador, Italy, Florida, New Zealand, Cuba, and Formosa, and is also known in India. Several of these areas are either in or near the tropics.

It seems probable that this fungus was introduced into Europe from the Andes where it is known to attack the wild form of potatoes, but was not brought into Europe along with the first introduction of potatoes in the sixteenth century from South America, the original home of the potato, the reason being that a prolonged exposure to a temperature of over 77°F. is fatal to the fungus. With the advent of steam-driven vessels, in the decade 1830 to 1840, the journey between South America and Europe could be completed in much fewer days than before and so it is very likely that the fungus in these vessels was able to cross the zone of tropical temperature intervening between its home and Europe. From Europe it was introduced into India along with the importation of large quantities of seed tubers from infected countries such as England. In the Sikkim Himalayas this exotic parasite found a suitable locality to establish itself and in Darjeeling the potato crop became blighted first in 1883, shortly after the introduction of English varieties. In the latter place the local varieties were at first more affected, not being acclimatized to the disease and therefore less resistant. In the Annual Report of the Royal Botanic Garden, Calcutta, it is stated that the acclimatized English potatoes turned out badly in 1886, not only those grown in the Lloyd Botanic Garden at Darjeeling but also those grown by private cultivators. The deterioration in quality was accompanied by impaired resisting power and in 1887 they became badly diseased. At the same time from the Sikkim Himalayas the disease spread to Nepal and Bhutan. In the Khasi Hills the blight was first found in 1885 and in 1887 there was an epidemic. Dr. Butler, in the *Agricultural Ledger*, X, 1903, has pointed out that the appearance of the disease in the Khasi Hills two years after its appearance in the Sikkim Himalayas suggests infection from this source either by exportation or continuous extension through Bhutan.

Cunningham in 1897 records the presence of the potato *Phytophthora* from Kumaun; this shows that the disease had spread also westward along the Great Range.

Dr. Butler in the *Agricultural Ledger*, X, 1903, mentions that specimens of diseased potatoes received from the Native State of Kumharsain, north of Simla, sent to him in 1902, were found to be attacked by *Phytophthora.*

Though the potato disease was known in Northern India at high altitudes in 1883, still before 1900 it was unknown on the plains. For the first time in 1899-1900 a few potato fields in the Hooghly District were observed to be diseased, the damage being slight; in 1900-1901, the blight became worse and in 1901 and 1902, it prevailed epidemically and extended through the whole district. It is reasonable to suppose that this outbreak was due to the use of diseased tubers got from localities such as Darjeeling or Naini Tal.

The fungus can exist only at low temperatures and those prevalent in the summer months on the Bengal plains are much higher than the thermal death temperature required for the fungus in the tubers and therefore under ordinary storage conditions, the potatoes would get disinfected of the fungus and so also would be the soil of the blighted fields. Later experience has shown this to be the case. There are two probabilities, either or both of which may have led to the occurrence of the disease for three successive years in the Hooghly District. One is that the potato-growers during these years may have been importing hill potatoes in the beginning of winter or in the end of summer when the temperature would not be high enough to kill the fungus in the seed tubers; the other probability is that the seed tubers may have been stored in such a way as to keep them at low temperatures. The first probability does not readily explain the reported gradual extension of the blight from a centre at Singur to the whole Hooghly District. The second probability seems to be doubtful; but there is one consideration which may be taken into account. If the seed tubers are heaped together in a large bulk, the outside high temperature may not be perhaps able to penetrate to the centre of the heap which, therefore, besides being moist, may also remain at a temperature low enough

not to kill the fungus, if present in the tubers. When the blight raged for three years on the plains of Bengal it was feared that it had come to stay; fortunately this fear has not been realized for after 1903 it disappeared.

It is not only in India that the blight has somehow been able to occur for three successive years in a district in which the fungus ordinarily cannot survive the hot summer. In America, in the northern Mississippi valley the potato sections of Michigan, Wisconsin and Minnesota, where the summers are too dry and warm to allow the fungus to spread, were swept by the late blight for two successive years, 1902-04 ; before that for twenty years the disease had not been observed there and since then has disappeared.

After 1903 the blight was not known in any part of the plains of India for about a decade. In 1912 and 1913 it was reported from Jorhat Farm (Assam); in 1913 from Rangpur (Bengal) and Bhagalpur (Bihar) and in 1916 from Karimganj Farm (Sylhet).

The causes of the occurrence of the blight in some of the above places have been investigated and the results are of interest.

Jorhat Farm. The variety called " Darjeeling Potatoes " from Darjeeling was received and planted at Jorhat in November, 1911, and the disease appeared the following February. We know that the blight is present in Darjeeling and therefore some of the " Darjeeling Potatoes " got by the Farm, may well have been infected. At Jorhat the normals of maximum and minimum temperatures in November are 81·5°F. and 59·7°F. The maximum temperature, therefore, is not high enough to kill the fungus in the tuber in the short time that it might be exposed under storage conditions to temperatures above 77°F.; when the seed tubers are sown they would be under moist surroundings and the maximum temperature at the depth of 4 to 6 inches, the depth at which potatoes are usually sown, would be lower than 81·5°F., the maximum air temperature. (In this connection it may be pointed out that according to Leather the maximum air-temperature in the shade at Pusa (Bihar) in November is higher by about 5·5°F. than the maximum soil-temperature at the depth of 6 inches.) The use of diseased seed tubers and the occurrence of low temperatures at the time of sowing

would not by themselves lead to an epidemic unless at the time when the plants usually get infected, the weather is also moist and cloudy, because excessive humidity is a potent factor in the spread of an epidemic. In February, 1912, at Jorhat there was a fall of about two inches of rain, and in the months of January and February the humidity is also very high, the normals of relative humidity for these months being 95 per cent. and 94 per cent. Thus we see that for the potato season 1911-12 at Jorhat there was an accumulation of all those factors which can lead to an epidemic, and therefore naturally there was one.

In 1912-13 potatoes were obtained from Shillong, where the blight is known, and again the disease appeared, one variety known as " Khasi Nainital " being completely killed out. "Khasi Nainital" was once a resistant variety but Mr. Birt, Deputy Director of Agriculture, Assam, in his report on the Upper Shillong Agricultural Experiment Station for the year ending June 30th, 1913, states that " Khasi Nainital " has become susceptible to disease. The seed tubers may have been obtained at the time of sowing in November as in the previous year ; in February, 1913, the rainfall was over 4 inches ; and therefore it is natural that there was again an occurrence of the disease.

From that time no potatoes were grown on the Jorhat Farm until last cold weather when the variety " Up-to-date " was sown. This variety, which gave a healthy crop, was got from Shillong, where it is grown as a resistant kind.

Bhagalpur District. In 1912 the local store of seed tubers was almost entirely destroyed by *Rhizoctonia* and potato moth. Consequently there was a much larger import of the hill varieties from Darjeeling and Naini Tal than in previous years and therefore in all probability a large quantity of infected seed tubers was received. Again in ordinary years the hill varieties are sown late but in 1912 they were sown early, instead of the local varieties ; on the Sabour Agricultural Farm, they were sown in October, almost immediately after they were received ; and the local cultivators seem to have done the same. Therefore the fungus in the diseased seed tubers, if present, was not killed at the time of sowing, the tubers

having escaped the dry heat of the plains under storage conditions. In the latter half of December this district had the Christmas rains and after that the weather remained extremely moist, foggy and cloudy and the temperature was very low; these were favourable conditions for the rapid spread of the disease, if present. In the beginning of January most of the potato fields were completely destroyed by the blight. Here we once more see that the cause of the epidemic was the coincidence of several factors: *first*, the getting of seed tubers in large quantities from infected localities so that some, if not many, must have been diseased; *secondly*, sowing the seed early and thereby not disinfecting the tubers by exposing them sufficiently long under ordinary storage conditions to the temperature prevalent in October which is high enough for the purpose; *thirdly*, Christmas rains; and *fourthly*, a spell of cloudy and foggy weather charged with high humidity at the time when the crop was almost mature.

In 1913-14, on the Sabour Agricultural College Farm, tubers picked from infected fields of the previous season were used as seed, and gave a crop free from *Phytophthora;* also in the Bhagalpur District some cultivators resowed the blighted fields with seeds collected from the infected crops of 1912-13 for the new season without any bad effect. Again in Rangpur Farm one potato plot that was blighted in 1912 grew a healthy crop of potatoes in 1913.

These results show that on the plains the fungus is not able to survive the heat of the summer months both in the soil and in the tubers.

Sylhet. This year in March, blighted potatoes (variety "Arran Chief") were received for examination at Pusa from Karimganj Farm, Sylhet, where late blight was never known before. This variety was received from England in the first week of November and was sown a week later. The natural inference is that the disease was introduced through infected seed tubers.

In Southern India, the Nilgiris seem to be a likely locality where the potato disease could exist on account of the high altitude. In 1902, Dr. Butler made inquiries regarding its presence from the Nilgiri Agri-Horticultural Society and the results of these inquiries

are given by him in the *Agricultural Ledger*, X, 1903, where he says: "There seems to be a general agreement amongst the members of the Nilgiri Agri-Horticultural Society that the disease prevalent is the potato blight." The Honorary Secretary stated: "The disease is no doubt the common Irish blight, caused by a fungus. It has been noticed on these hills for the past 25 to 30 years." Major-General H. R. Morgan's account of a disease attacking tomatoes and potatoes in the Proceedings of the Society for the 10th August, 1900, makes it probable that *Phytophthora* was the cause of the disease. Dr. Butler concludes the results of his inquiries with the following statement: "It is certain, therefore, that disease is very prevalent in the Nilgiris and is extending its ravages, and a part at least of the damage is to be attributed to *Phytophthora*." But Mr. McRae, Government Mycologist, Madras, in reply to my inquiries made recently, informs me that he has not come across *Phytophthora infestans* in the Nilgiris.

In Bombay, potatoes are grown extensively on Mahabaleshwar hills but so far no *Phytophthora* disease is known to occur there. The chief source of Bombay's foreign supply of seed potatoes is Italy; but seeds from England and Ireland have been tried on a small scale at Dharwar in past years; the resulting crop was unsatisfactory on account of its low yield but it was free from disease.

From the above account we see that in India *Phytophthora infestans* is to be found, with certainty, only in Northern India and that too at high altitudes. At times this blight has also been found on the plains but the epidemic has always been sporadic and the origin of the disease has been traced (in those cases that have been investigated) to the sowing of diseased seed tubers got from infected sections after the end of summer.

This is a very fortunate find for this precludes the possibility of the fungus establishing itself in the plains and therefore potatoes of excellent quality but susceptible to the disease in the hills of Northern India and foreign countries, can be grown on the plains without their being blighted, provided they are imported in summer when the temperature is high enough to kill the fungus in the tuber under ordinary storage conditions.

A STUDY OF THE ARROWING (FLOWERING) IN THE SUGARCANE WITH SPECIAL REFERENCE TO SELFING AND CROSSING OPERATIONS.

BY

T. S. VENKATARAMAN, B.A.,

Assistant to the Government Sugarcane Expert, Madras.

I. INTRODUCTION.

THE breeding of new sugarcane varieties by raising canes from seed—instead of from cuttings as is ordinarily done by the ryot—is now widely recognized as a sound method of improving the sugar industry of any country. In India the sugarcane flowers but rarely and, even when it does so, the flowers are so often sterile that any light that can be thrown on the causes and conditions which lead to arrowing in the cane or influence the fertility of the arrow is likely to be of great value.

II. CONDITIONS WHICH CONDUCE TO ARROWING IN THE SUGARCANE.

It may be that certain of the varieties can never be made to arrow, but experience gained at the Sugarcane Breeding Station (Coimbatore) during the last four years shows that, with a certain amount of careful manipulation, more varieties can be made to arrow than do so at present. In a study of the conditions which lead to arrowing in the cane, there often exists such a large combination of factors that it is not always easy to judge as to the deciding ones. Below are considered some of the more important ones.

(1) *Geographical position.* The geographical position of any locality with the implied soil, climatic and meteorological conditions appears to be a factor of importance. (*a*) At Bangalore, for instance,

not only do the same varieties appear to arrow more profusely than at Coimbatore, but the collections from the former place have for two years shown a higher germination. In the years 1914 and 1916 arrows of *Striped Mauritius* from Bangalore gave an average germination per seed pan of 60 and 140 seedlings respectively, as against Coimbatore *Striped Mauritius* which gave only 13 and 88. (*b*) Many canes not known to flower in North India have done so freely when introduced at Coimbatore. Such are *Lata, Hemja,* and *Paunri* besides many others. (*c*) The same variety arrowing in North India and Coimbatore shows a comparatively higher percentage of open anthers, *i.e.*, a higher degree of male fertility, in the latter place (*Cf.* Table below).

TABLE I.

Name of Variety	Percentage of open anthers at				
	Pusa	Sepaya	Shahjahan-pur	Adhartal	Coimbatore
Saretha	4	0	0	0	90
Cheni	3	..	..	1	95
Kholia	..	1·3	..	..	90

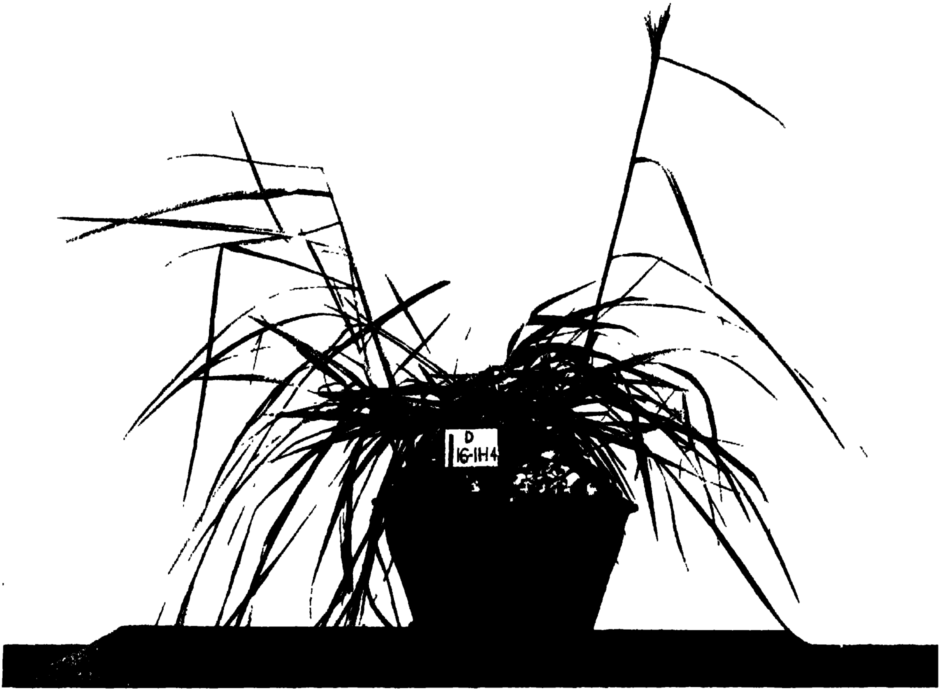
(2) *Rainfall.* Under Coimbatore conditions a comparatively large amount of rain during the period of active growth in the cane appears to conduce to arrowing. We had a much larger number of varieties arrowing in the years 1915 and 1916 than in 1913 and 1914, and the following table of rainfall during these four years is of interest.

TABLE II.

Year	Rainfall in inches—April to October	Total number of varieties that arrowed
1913	5·36	None.
1914	5·67	5 thick and 4 thin canes.
1915	13·41	35 thick and 36 thin canes.
1916	13·43	62 thick and 34 thin canes.

Note. The canes did not grow very well in the earlier years and it may be that this accounts for part of the difference.

PLATE V



This pot plant of Madras seedling No 2 arrowed, though but 4 months old, while others of the same kind and age planted in the ground did not do so. The arrow is here seen coming out of the leaf sheath.



Shows profuse arrowing in one of the "Arrowing plots" at the Cane Breeding Station, Coimbatore.

(3) *Interference with the vegetative growth.* Interference with the vegetative growth of the plant induces arrowing. In the year 1914 a four-month-old plant of Madras seedling No. 2, which had to be kept growing in a pot in connection with the study of depressed habit in canes, arrowed, whereas others of the same kind and age planted in the ground did not do so. (Plate VI.) The pot plant was noted to be badly pot-bound. In the year 1916 three varieties of canes imported direct from Java and planted partly in pots and partly in the ground behaved in a similar manner. It is proposed in future years to use this method (1) to induce arrowing in reluctant varieties and (2) to hasten the arrowing in North Indian canes. Very recently, however, a plant of *Saccharum arundinaceum* directly imported from Java and planted in the ground arrowed, while another planted in a pot did not do so.

(4) *Time of planting and the kind of soil in which the crop is planted.* The time of planting together with the nature of the soil in which the canes are planted appears to be factors of importance. In Coimbatore it is found that in garden lands the varieties have to be planted some time between August and November the previous year to induce copious arrowing. Under wet land conditions, however, varieties planted even as late as March or April of the same year have been known to arrow. The arrowing plots laid at the Cane Breeding Station on the above ideas have amply justified themselves.

(5) *Arrowing as a character of a group or class.* Certain classes of canes flower freely year after year while others do not flower at all or do so but scantily. Among the North Indian canes the *Saretha* group flowers freely year after year while those of the *Sunnabile* group do so but rarely. The *Mungo* group arrows but rarely and even when it does, the anthers do not protrude properly and occasionally the arrows themselves soon dry up. The *Nargori* group is often characterized by the smothering of arrows. Plate VII shows arrows of *Katai*, a member of the *Nargori* group, and is interesting as showing the apparent reluctance of the arrows to come out of their leaf sheaths. A profuse arrowing has been noted in seedlings with wild blood and in "Rogues."

"Rogues" are plants which occasionally appear in some batches of seedlings, are strikingly different from the rest, and breed true when selfed (*vide* Bateson and Pillcw, *Journal of Genetics*, July 1915, page 13).

III. Time and sequence of arrowing.

In Coimbatore the arrowing season commences about the end of September and extends to about the middle of January. During this period the different varieties show a marked and fairly well-defined sequence in arrowing, other conditions being equal.

Thick canes. Among the thick canes *Vellai* is the earliest to arrow and commences with the first week of October. It is followed by *Karun*, *Chittan* and *Kaludai Boothan* which arrow during the second and third weeks of October. *D.* 74, *Mauritius* 16, and *Java* (Hebbal) follow next, while *B.* 1528, *Pachrangi* and the Moradabad varieties bring up the rear commencing to flower as late as the middle of November.

Thin canes. Among the thin canes those of the *Pansahi* alliance are the first to flower and do so by about the end of October. These are closely followed by those of the *Saretha* alliance and a little later by those, if any, of the *Nargori* and *Mungo* alliance. This difference is so striking that, in the year 1915, some mistakes in grouping became quite evident as the arrowing season came round.

"Rogues" and plants with wild blood. "Rogues" and canes with *Saccharum spontaneum* or *Naanal* blood arrow simultaneously with the earliest of the thick canes or a little later. This has enabled a number of possibly useful crosses to be attempted during the 1916 arrowing campaign.

For two years seedlings obtained by crossing *Vellai* with *Saccharum Narenga* have been noted to arrow as early as the last week of August, *i.e.*, about a month prior to the arrowing of the bulk of the other canes. This is interesting in view of the fact that *Narenga*, the father in the above cross, begins to arrow as early as the second week of August and has a long and unrestrained period.



A plot of *Vellai* x *Saccharum Narenga* seedlings showing profuse arrowing.



Arrows of *Katai,* a member of the *Nargori* group. The arrows do not freely come out of their leaf sheaths.

The above observations have been of considerable value, not only in ascertaining the probable parentage of seedlings raised from unbagged arrows but also in showing that it is not always possible to effect crosses between varieties as we desire.

IV. ATTEMPTS TO INDUCE THE THICK AND THIN CANES TO ARROW SIMULTANEOUSLY.

The great aim of the Cane Breeding Station is to produce a good cane which will grow under North Indian conditions, and it was early realized that the greatest chances of success lay in a cross between the indigenous thin hardy but comparatively poor cane of North India with the thick, rich, apparently introduced, juicy canes of South India. It was soon found, however, that this was rendered difficult, if not impossible, by the fact that the two classes of canes arrowed at different times, the bulk of the thick canes being out by the time the arrowing of the thin canes comes into full swing. A persistent attempt is therefore being made to make the two arrowings approximate if not overlap.

An attempt to retard the time of arrowing in the thick canes has hitherto failed. A series of *Vellai* canes planted monthly between December 1914 and March 1915, arrowed practically together during October 1915. A hastening in the thin canes has, however, been secured by (1) planting in heavy stiff garden land the previous November and (2) planting under wet land conditions in March or April of the same year. (*Cf.* Table below.)

TABLE III.

Variety	Pansahi	Sanachi	Khelia	Katha	Cheni
Date of arrowing. Crop planted in heavy stiff garden land, November 1914	26th Oct.	27th Oct.	26th Oct.	Not planted.	27th Nov.
Date of arrowing. Crop planted under wet land conditions, April 1915	27th Oct.	29th Oct.	26th Oct.	6th Nov.	21st Nov.
Date of arrowing. Crop planted in garden land, February 1915 ..	15th Nov.	16th Nov.	2nd Nov.	20th Nov.	Did not arrow.

But this hastening by about a fortnight is not found sufficient. It has secured this year the possibility of a cross with the late

flowering thick canes, such as *D.* 74, *B.* 3412, and *Mauritius* 16. Further attempts will be directed at securing, if possible, a further hastening of the thin canes so as to bring it into a line with that of varieties, such as *Vellai, Ashy Mauritius* and *Green Sport of Striped Mauritius*.

V. STUDY OF THE CANE ARROW.

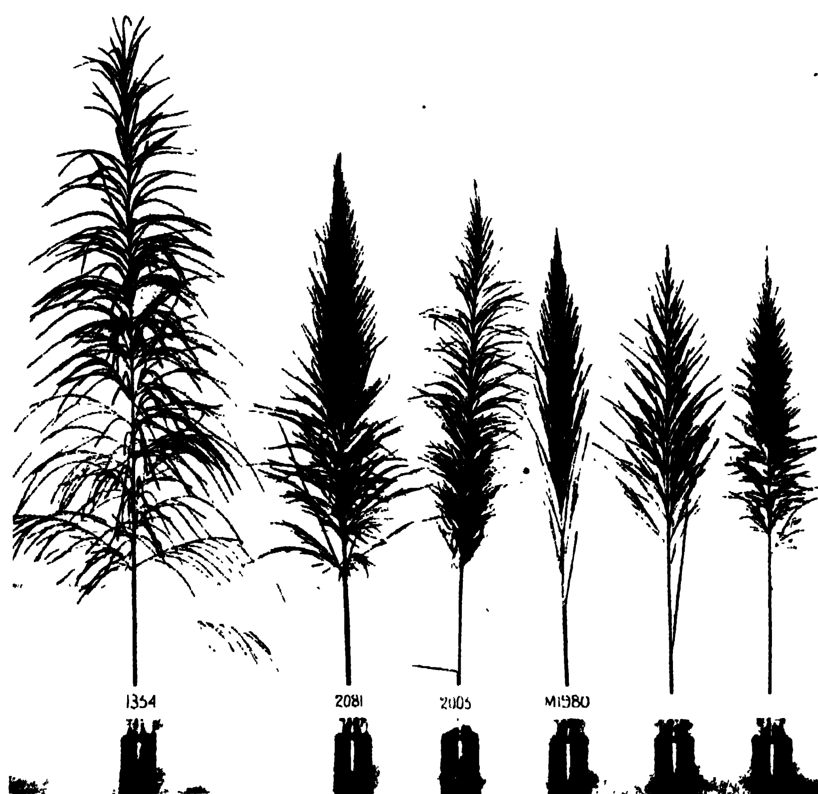
Morphological differences. Even as early as 1912 it was noticed that arrows of different cane varieties markedly differed from one another as regards colour, size, shape, etc. At Singanallore, it was found possible even among closely allied kinds to tell the variety growing in any field by merely looking at the arrow. As more and more varieties arrowed in subsequent years, it was found that the arrows differed in many other characters besides, such as shape of the axis, vestiture on the axis, arrangement and disposition of the branches, etc. But pressure of more important work prevented a detailed study on this line.

Study of male fertility. It was also found that arrows exhibited certain interesting differences in their relative male fertility as judged by (1) the percentage of open anthers and (2) the presence or absence of starch in the pollen grains. This led to important results as we shall presently see.

(*a*) *Difference between varieties.* Varieties were found to differ from one another in the relative degree of male fertility. This has enabled the separation of a certain group of canes with comparatively poor male fertility to be used as "mothers" in crossing operations. The importance of this will be understood when it is mentioned that, because of the extremely delicate nature of the cane flowers, it is extremely difficult to attempt emasculation and hand pollination, as even a slight permanent bending of the inflorescence has been known to kill the flowers. It is reported from Cuba that four years of continuous work yielded only two seedlings.

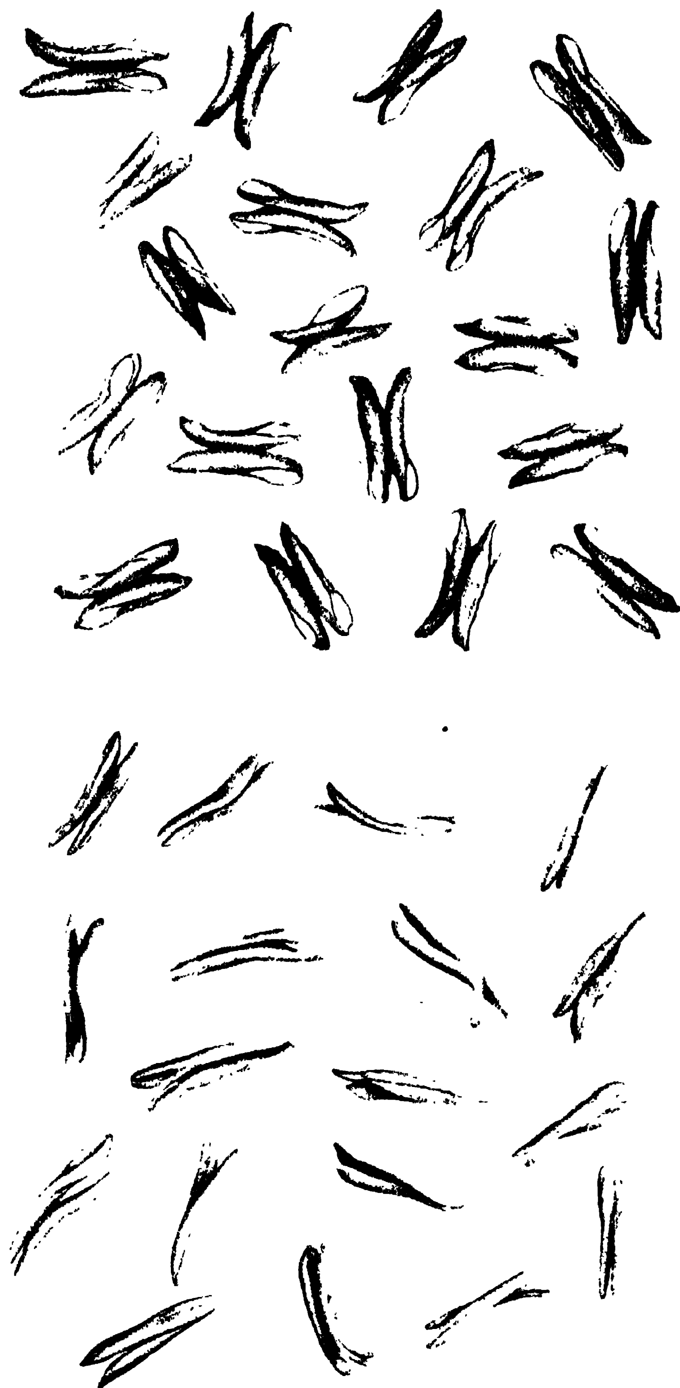
The following have been separated as "mothers" up to date (4th November, 1916):—(1) *Vellai, J.* 36, *J.* 213, *Mauritius* 1237, *Yerra, Louisiana Purple, Green Mauritius;* (2) *Madras Seedlings* 4316,

PLATE VIII.



Arrows of different Sugarcanes differ from one another in morphological characters.

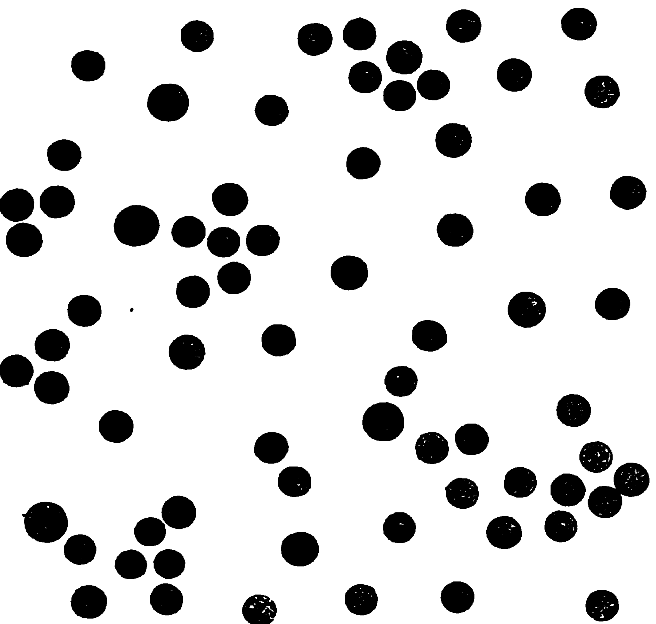
SUGARCANE ANTHERS.



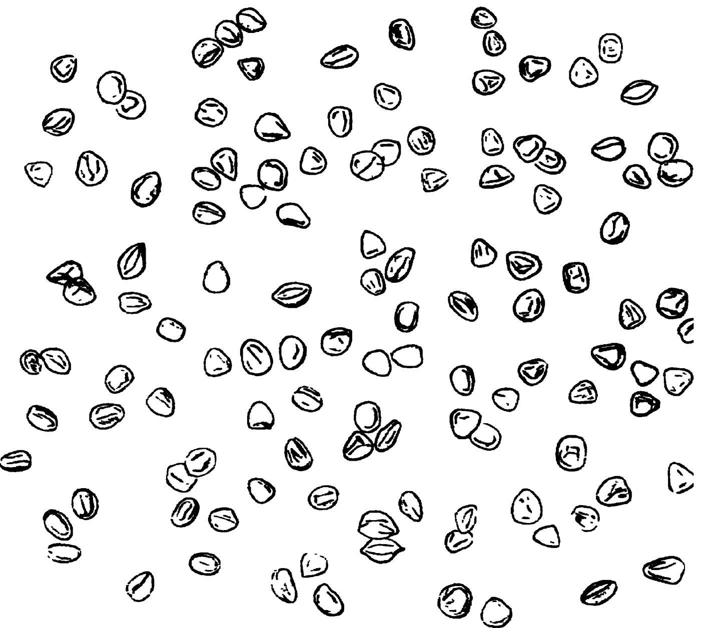
Closed (Variety *Vellai.*)

Open (Variety *Green Sport* of *Striped Mauritius.*)

SUGARCANE POLLEN.



Healthy Grains.
Circular in outline, granular in appearance and staining dark blue with iodine (Variety *Saretha*).



Unhealthy Grains.
Irregular in outline, appearing devoid of contents and not staining with iodine (Variety *Vellai*).

2950, and 6621 ; (3) the *Pansahi* group. Every attempt is constantly being made to add to the above list.

Not only individual varieties but different groups show characteristic differences in this respect (compare *Saretha* and *Pansahi* groups in the Table below).

TABLE IV.

Pansahi group				Saretha group			
Variety	Anthesis			Variety	Anthesis		
	Open %	Slightly open %	Closed %		Open %	Slightly open %	Closed %
Pansahi ..	0	2	98	Saretha ..	97	0	3
Merthi ..	5	10	85	Lalri ..	95	0	5
Dikchan ..	11	6	83	Saretha desi ..	97	1	2
Sanachi ..	3	9	88	Messangen ..	91	0	9
Kahu ..	1	2	97	Katha ..	95	0	5
Manoria ..	0	5	95	Kansar ..	96	0	4

(*b*) *Difference between plant and ratoon crop.* In the same variety the arrows obtained from ratoon crops show a higher degree of male fertility than those from plant crops. (*Cf.* Table below.)

TABLE V.

Name of variety	Percentage of open anthers	
	In plant crop	In ratoon crop
Vellai, Cane-Breeding Station, Coimbatore ..	0	1—7
Vellai, Central Farm, Coimbatore ..	0	10—41
Karun, Cane-Breeding Station, Coimbatore ..	35—61	92
Kaludai Boothan Do. ..	77	90

(*c*) *Difference between the different parts of the same arrow.* The basal florets of an arrow are found to possess a comparatively smaller percentage of open anthers than those of the rest of the arrow. In the cane arrow the protrusion of anthers is from above downwards and the above conclusion was arrived at by an

examination of the anthers collected on successive days. (*Cf.* Table below.)

TABLE VI.

KARUN			KALUDAI BOOTHAN			FIJI C		
Date of Coll.	Open anthers %	Closed anthers %	Date of Coll.	Open anthers %	Closed anthers %	Date of Coll.	Open anthers %	Closed anthers %
27th Oct. ..	60	39				21st Nov.	96	4
29th „ ..	68	32	31st Oct.	91	9	26th „	96	4
31st „ ..	73	27	2nd Nov.	90	10	3rd Dec.	25	75
6th Nov. ..	57	43	6th „	76	24	5th „	24	76
9th „ ..	29	71						

PANSAHI			M. 2217			SARETHA		
Date of Coll.	Open anthers %	Closed anthers %	Date of Coll.	Open anthers %	Closed anthers %	Date of Coll.	Open anthers %	Closed anthers %
21st Nov. ..	6	94	27th Oct.	98	2	8th Nov.	70	30
26th „ ..	6	94	31st „	90	10	9th „	89	11
3rd Dec ..	4	96	9th Nov.	74	26	11th „	85	15
5th „ ..	1	99				12th „	53	47
						13th „	46	54

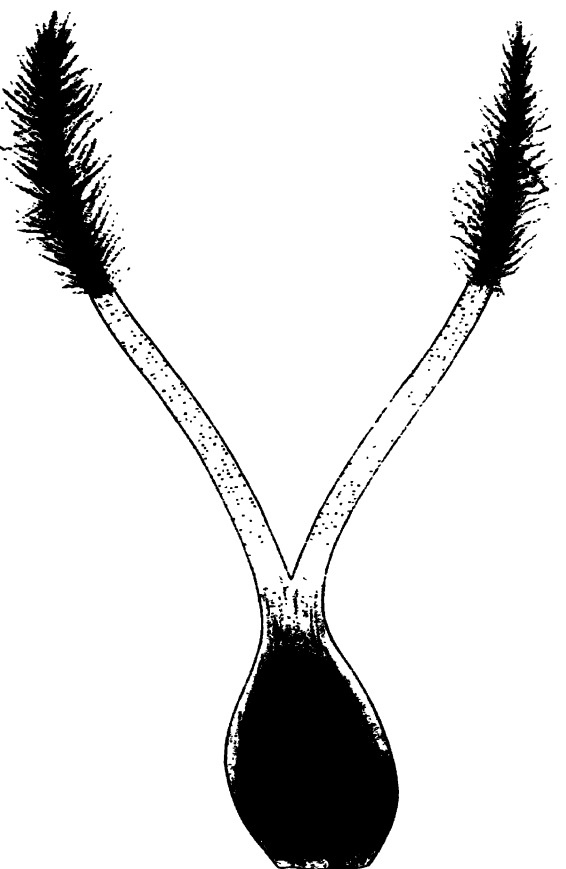
The above statements further show that the highest percentage is at the top or near it. This observation has had one practical result. In making general collections of arrows we now collect only the top halves with the result that with a smaller number of seed pans we obtain a large number of seedlings.

(*d*) *Difference between "Early" and "Late" Cane.* In a paper on Punjab canes by Dr. C. A. Barber[1] mention is made of certain varieties which show two different kinds of canes in the same clump called 'Early' and 'Late'—the two kinds differing not only in certain morphological characters but also in age. In a subsequent publication by the same author[2] the chemical difference between the above two kinds were considered. The arrowing work during the year 1915 showed differences in the degree of male fertility between these two kinds (*Cf.* Table below).

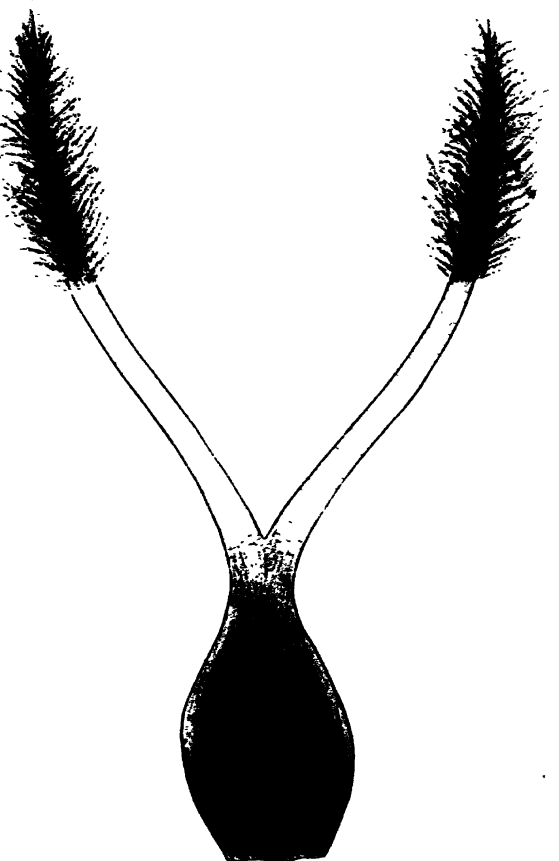
[1] Barber, C. A., *Mem. Dept. of Agri., India, Bot. Series*, vol. VII, no. 1.
[2] Barber, C. A., *Mem Dept. of Agri, India, Bot Series*, vol. VIII, no 3.

PLATE XI.

DIAGRAM OF TWO KINDS OF PISTILS IN THE SUGARCANE.



Fertile.



Infertile.

TABLE VII.

Agol				Ketari				Kahu			
Kind of cane	Anthesis			Kind of cane	Anthesis			Kind of cane	Anthesis		
	Open %	Slightly open %	Closed %		Open %	Slightly open %	Closed %		Open %	Slightly open %	Closed %
Early..	0	4	96	Early..	8	7	85	Early..	2	8	90
Inter ..	4	11	85	Inter..	16	12	72	Late ..	22	15	63
Late ..	40	28	32	Inter & late	54	46	0				

This observation is of importance in selfing and crossing as it enables one to select from among the arrows of the same variety which to self and which to cross.

Study of female fertility. During the course of the arrow work it was frequently found that certain of the varieties when cross-pollinated would not set seed or do so but sparsely, though the pollen used was fresh and apparently quite normal. This suggested the possibility that different arrows may show differences in female or pistil fertility similar to what has already been found as regards male fertility. After a number of trials it was found that in varieties such as *J.* 36, *M.* 2806, and *Saccharum Munja* which persistently refused to set seed, the cells in the style branches were devoid of starch. In varieties which set seed freely, on the other hand, such as those of the *Saretha* group, the style branches showed a good amount of these grains scattered all through. The test is quite simple and all that is needed is to dissect the pistils, mount in iodine and water and examine for starch. The list of " mothers " is now being revised on this basis and it is claimed that the above observation will prevent a good amount of useless bagging and allow concentration of energies on those which are most likely to give the best results. *J.* 213, which was selected as a good mother after the above examination, has amply justified the selection and yielded over 700 supposed crosses from 4 seed pans.

VI. Certain arrow abnormalities.

In the course of the work certain interesting arrow abnormalities were found, some of which are just mentioned here. In the arrows of *Katai* and *Agaule* No. 2, neither the stigmas nor the anthers are protruded, the anther filaments being noted to be particularly short in the latter. In the arrows of *M.* 841 and *M.* 1198 no anthers are ever seen outside the glumes and some sort of self-pollination was suspected, but selfed arrows produced no seedlings.

VII. Selfing operations.

For purposes of selfing the arrows are enclosed in muslin bags before they come out of the leaf sheaths and the bags are allowed to remain practically till the arrow is ready for harvest. It has been frequently noticed that unbagged arrows gave a better germination than the bagged ones, the latter occasionally showing complete failure. (*Cf.* Table below.)

Table VIII.

Variety	Nature of collection	No. of pans sown	Average germination per pan
Karun	Unbagged ..	42	5
	Bagged .	11	0
Kaludai Boothan ..	Unbagged ..	30	100
	Bagged ..	9	0
Striped Mauritius (Hebbal)	Unbagged ..	28	71
	Bagged ..	2	6
Pansahi	Unbagged ..	4	23
	Bagged ..	2	3
Khelia	Unbagged ..	6	50
	Bagged .	3	15
Saretha	Unbagged ..	12	116
	Bagged ..	3	133

In preparing the above statement care has been taken to see that the lots compared are from the same place and collected at

about the same time. It is found that the thin canes apparently suffer less from the effects of bagging than the thick ones. In view of the above an attempt was made to see if the conditions inside the bags are in any way abnormal and a series of thermometer readings inside and outside bags showed that it was so (*Cf.* Table below).

TABLE IX.

Date, time of observation, and note on weather		Thermometer readings		
		In the open	Inside bamboo	Inside iron cage
12th October, passing showers	Morning	72	78	
	Noon	92	98	
	Evening	75	77	
13th October, thunderstormy	Morning	74	82	
	Noon	87	97	
	Evening	74	77	
14th October, thunderstormy	Morning	74	72	
	Noon	89	99	
	Evening	70	72	
19th October, passing showers	Morning	74	75	76
	Noon	84	89	90
	Evening	76	76	77
20th October, cloudy	Morning	73	74	74
	Noon	85	93	93
	Evening	75	78	78
26th October, distant lightning	Morning	67	67	68
	Noon	90	94	97
	Evening	78	78	80

The temperature inside is found to be higher than that outside occasionally by even as much as 10 degrees, and this extreme difference is found on days characterized as thunderstormy. Inside an iron cage the temperatures are even higher still, and this fact justifies the large use of bamboo cages in recent years.

VIII. CROSSING OPERATIONS.

Because of the poor and comparatively slow results obtained in other countries by actual emasculation and cross-pollination by hand, it was early realized that this method was unsuited for the purposes of the station which was sanctioned only for five years. Many

other methods of securing cross-pollination, such as (1) planting the pollen-fertile and pollen-sterile varieties in alternate rows or in chess-board fashion, and (2) enclosing in one and the same bag the two arrows which it is desired to cross, were tried, but had to be given up either because of certain practical difficulties or because of comparative uncertainty as regards parentage of the resultant seedlings. Three different methods have been evolved and are in current practice.

(1) The arrow which is desired to use as father is cut the previous evening, the base of the stalk stuck into a 2 lb. bottle containing water and hung up inside the bag of the mother arrow. Next morning the anthers protrude, liberate the pollen, and thus cross-pollination is secured. The complete liberation of the pollen is frequently secured by gently tapping the arrow at about 10 A.M., next day. This method has so far been successful but has this disadvantage that it is not possible to collect the anthers of the mother arrow alone separately in order to form some idea as to possibilities of selfing.

(2) Fresh pollen is collected in the morning from the father arrows and poured on the stigmas of the mother arrow as soon as collected. In recent years, especially when the quantity of pollen is scanty, both economy and efficiency have been secured by filling empty gelatine capsules with pollen and spraying it on to the stigmas with the help of a "larva-blowing apparatus."

(3) Obtaining by post gelatine capsules charged with the desired pollen and spraying it on to the stigmas with a larva-blowing apparatus. Because of the practically uniform failure of this method, it is thought possible that the pollen loses its vitality during transport.

In all the above attempts at crossing there is always the likelihood that some of the resultant seedlings may be merely selfed, but by the selection of varieties which are practically pollen-sterile as "mothers" such chances are considerably reduced.

I am greatly indebted to Dr. C. A. Barber for advice and for freely affording facilities to carry on the work described above.

SOME ENZYMES OF GERMINATING RED GRAM (*CAJANUS INDICUS*).

BY

B. VISWANATH,

Assistant to the Government Agricultural Chemist, Madras.

In a previous paper on "Some Factors affecting the Cooking of Dholl" (*Memoirs, Dept. Agri., India, Chem. Series*, vol. IV. no. 5) it was shown that the practice of treating the seeds of the gram with red earth and water for a certain time before being made into dholl, does not accelerate the rate of cooking and that the presence of amylolytic and other enzymes was noticed in the grain so treated. As this treatment induces incipient germination it was thought desirable to make a study of the enzymes in the germinated seed.

A quantity of red gram was, therefore, allowed to germinate for four days at the end of which period the sprouts were about an inch long. They were then dried first in the shade for a few hours and then in the sun till completely dry. An aqueous extract of the powdered material thus obtained possessed strong enzymic properties.

It was ascertained from experiment that the enzymes obtained from this solution by precipitation methods were much weaker than was the fresh aqueous extract and in addition it was not possible to effect a complete separation of the individual enzymes, such attempts resulting in diminution or entire destruction of the activity of the material under examination. An aqueous extract of the germinated gram was, therefore, used in the experiments mentioned in this paper.

The study of the enzymes was limited to their behaviour towards (i) proteins, (ii) carbohydrates, (iii) such oxidizable substances as phenols. (iv) oils and fats, (v) milk, and (vi) amino compounds.

As the usual methods of examination are well known no attempt is made to describe them at length, except where necessary, for fear of needlessly lengthening the paper.

The temperature at which the enzymic action was studied was always between 35° and 40° C., unless otherwise stated, as in the case of determinations of optimum temperatures.

I. Behaviour towards proteins.

In the study of proteolytic enzymes the nature of enzymic activity was determined by testing the products of hydrolysis for peptones and tryptophane. The biuret test for peptones and the acetic acid and bromine method for tryptophane were adopted.

In testing for tryptophane the liquid was first acidified with strong acetic acid and bromine water was then added drop by drop. The production of a pink to red colour showed the presence of tryptophane and the depth of colour is approximately a measure of the quantity produced.

A one per cent. aqueous extract of the germinated dholl was added to test tubes containing thin slices of hard boiled egg albumin or fibrin and then incubated for ten days with the addition of a little toluene to prevent bacterial decomposition taking place. At the end of this period it was found that the albumin and the fibrin were unchanged and that neither peptone nor tryptophane was produced.

Having thus failed to obtain evidence of proteolysis in the case of higher proteins as egg albumin and fibrin, experiments were made with simpler proteins such as gelatine and dholl protein. The results in this case were again negative. Negative results were also obtained when the extract was prepared by using a one per cent. solution of sodium chloride in place of distilled water and the same applies to experiments carried out under acid and alkaline conditions. In the latter case concentrations of 0·2 per cent. of hydrochloric acid or 1 per cent. of sodium carbonate were employed.

It is, thus, evident from these experiments that neither the aqueous extract nor one per cent. sodium chloride extract of the germinated dholl has any action either in neutral, acid or alkaline conditions on egg albumin, fibrin, gelatine and dholl protein.

This being the case, the action of the extract on protein derivatives of a less complex nature than the proteins themselves was studied and for this purpose Witte's peptone was selected and 5 cc. of a one per cent. solution of Witte's peptone were put into each of two small flasks and 5 cc. of the aqueous extract added. Control experiments with Witte's peptone solution only and with the peptone solution to which the aqueous extract previously boiled was added, were started side by side for purposes of comparison. Toluene was added to all the flasks and their mouths were tightly plugged with cotton wool. After twenty-four hours of incubation the contents of the flasks were tested for tryptophane. The contents of the two flasks gave distinct tryptophane reaction while totally negative results were obtained with the contents of the controls. To eliminate all possibility of bacterial contamination the experiment was repeated a number of times with various antiseptics and positive results were always obtained :—

Particulars of experiment	Antiseptic used	Tryptophane test
Peptone solution + aqueous extract of the germinated dholl	0·03% HCN	Strong
Ditto	1·00% Chloroform	Distinct
Ditto	0·50% Salicylic acid	Faint
Ditto	1·00% Formalin	Faint
Ditto	0·20% $HgCl_2$	Strong

The behaviour of the aqueous extract in acid and alkaline media was next studied and it was found that the best results were obtained under alkaline and neutral conditions :—

Particulars of experiment	Medium	Tryptophane test
5 cc. peptone solution + 5 cc. of the aqueous extract	0·2% HCl	Distinct
Ditto	1·0% Na_2CO_3	Stronger than in the case of acid
Ditto	Neutral	Strong

These experiments demonstrate (1) the absence of enzymes capable of attacking proteins and (2) the presence of an enzyme which possesses the power of hydrolysing peptones into amino acids. The latter would therefore correspond to Vines's *ereptase* (*Ann. Bot.*, 1905-8-9). This being the case, it is difficult to conceive the utility of the presence of an enzyme of the character in a seed which contains about 23 per cent. of reserve protein when it is not associated with the presence of a protease to hydrolyse first the protein as is generally the case with most other seeds.

Vines (*loc. cit.*) calls attention to the fact that he found two separate enzymes in certain seeds and that each of them had to be extracted with a different solvent, namely, water and a solution of sodium chloride. In the light of these observations extracts of both normal and germinated seed with 1 per cent., 2 per cent. and 5 per cent. sodium chloride solutions were tested and in every case negative results were obtained, thus demonstrating the absence of peptase.

Dean, during the course of his investigations on *Phaseolus vulgaris* (*Bot. Gaz.*, 1905) did not find a peptase although the seeds contained much reserve protein which as he demonstrated underwent proteolysis before translocation took place; he, however, noticed ereptase in abundance. He considers that the protoplasm plays the part of a peptase while the ereptase may carry the digestion further.

It was, therefore, of interest to determine whether any evidence of proteolysis could be obtained during the later stages of germination and to this end a quantity of sound seed was germinated under as uniform conditions as possible and the seedlings obtained were then examined at different periods of germination.

With seedlings seven days old no evidence of proteolysis of the reserve protein was observed; but the action on Witte's peptone was energetic. In the case of seedlings ten days old, a faint tryptophane reaction was obtained with the freshly prepared aqueous extract which after twenty-four hours of incubation gave a very strong tryptophane reaction. This is suggestive of not only autolysis but

also a secretion of the enzyme peptase and in testing this point it was noticed that an aqueous extract of the seedlings was without any action on fibrin but actively attacked Witte's peptone; on the other hand, a one per cent. sodium chloride extract of the seedlings was found to attack both fibrin and Witte's peptone. If, in addition, the seedlings were first extracted with water and the residual mass then extracted with one per cent. sodium chloride, the NaCl extract was found to attack fibrin but was without any action on Witte's peptone.

With seedlings fifteen days old the results obtained were the same as those with seedlings ten days old. It was noticed that the enzymes acted better in neutral or alkaline media than in an acid medium. It may, therefore, be concluded that no peptase is present in the normal seed and that it is only developed as germination proceeds.

The action of the peptase, however, was so much weaker than the ereptase that, without further investigation, it cannot definitely be stated that the proteolysis of the reserve protein of the seed is entirely due to a specific enzyme secreted during the stage of germination. It is probable that this proteolysis is largely due to protoplasmic activity particularly during the early stages.

II. Behaviour towards carbohydrates.

A mixture of 25 cc. of 1 per cent. aqueous extract of the germinated dholl and 50 cc. of 2 per cent. starch paste, after twenty-four hours of incubation, produced no colour with iodine and reduced Fehling's solution, while in the case of a control experiment with boiled aqueous extract the blue colour with iodine and no reduction of Fehling's solution were observed.

The sugars formed were separated from the dextrine and the protein substances of the aqueous extract and their solutions were dextrorotatory. They were identified as maltose and dextrose by preparing their phenyl osazones and *p*-bromophenyl osazones and determining their melting points.

The enzymic action proceeds best under slightly acid conditions and in fact small amounts of alkali retard the action. The optimum

temperature lies between 55° and 60°C., and the antiseptics, toluene, chloroform, formalin, salicylic acid and mercuric chloride in concentrations of 3 per cent., 1 per cent., 0·5 per cent., 1 per cent. and 0·2 per cent., respectively, affect the action of the enzyme in an adverse manner. The retarding influence of these antiseptics is in the order given and in fact mercuric chloride produces almost complete paralysis.

The cell walls of thin sections of red gram seeds suspended in 5 cc. of the aqueous extract, with a little toluol, were found, under the microscope, to be disintegrating after 24 hours of incubation and almost completely disintegrated after 72 hours, while those suspended in the aqueous extract, previously boiled, were intact.

Again, a little ungelatinized starch and dholl powder were put separately into two small flasks and 10 cc. of the aqueous extract and a little toluene were added. After seventy-two hours 1 cc. of each of the solutions completely reduced 3 cc. of Fehling's solution. In the case of control experiments with the boiled aqueous extract only a faint reduction was noticed.

Equal quantities of a 3 per cent. maltose solution and a few drops of toluene were put into each of three sugar flasks. To one 10 cc. of the aqueous extract, to the second 10 cc. of the aqueous extract kept at 100°C. for 30 minutes were added and the third was left as it was. After seventy-two hours of incubation equal volumes of Fehling's solution were reduced by 35·0, 52·6 and 55·0 cc. respectively, of the three solutions. Since the cupric reducing power of maltose is less than that of dextrose the hydrolysis of maltose into dextrose is evident.

The aqueous extract is also found to invert sucrose in 10 per cent. solution. The hydrolysis proceeds best under slightly acid conditions and in fact it was found that, in a given time, about 7 per cent. of the sucrose was inverted in a slightly acid medium while only about 3·5 per cent. of the sucrose was inverted under conditions slightly alkaline.

With 3 per cent. toluene and 2 per cent. formalin as antiseptics the inversion of sucrose was only about 0·2 per cent., whereas with

1 per cent. chloroform and 0·1 per cent. salicylic acid the extent of inversion was about 4 per cent.

III. The presence of an oxidizing enzyme.

The presence of an oxidizing enzyme in the extract is readily demonstrated by adding a few drops of tincture guiacum when an intense blue colour is produced at once. Antiseptics such as mercuric chloride, formalin, toluene and salicylic acid appreciably retard the production of this colour but do not prevent its formation.

Hydroquinone in solution is rapidly oxidized by the enzyme with the production of an intense pink colour and of the production of quinone as shown by the characteristic smell. A solution of pyrogallol is oxidized with the production of a dark brown colour. In both cases control experiments performed with the extract after heating to 100°C. for thirty minutes were entirely negative.

IV. Enzyme hydrolysing oils and fats.

An enzyme of the type of lipase is present in the extract and causes the hydrolysis of such substances as ethylbutyrate and castor oil with the production of their respective fatty acids. In separate experiments with ethylbutyrate and castor oil, 26·0 cc. and 65·5 cc. respectively of N/100 KOH were required to neutralize the acidity resulting from their hydrolysis. In the case of control experiments with boiled aqueous extract practically no acid was produced in both the cases.

Chloroform, salicylic acid, formalin and mercuric chloride influence the activity of the enzyme adversely in the order named, the first being the most harmful.

V. A rennet-like enzyme.

The aqueous extract of the germinated dholl was also found to curdle carefully sterilized milk even when toluene was used as the antiseptic. In a control experiment, with the aqueous extract kept at 100°C. for thirty minutes, the milk was unchanged even after ten days.

No signs of proteolysis were noticed in the case of the curdled milk.

VI. Behaviour towards the amino compounds.

The presence of urease. A preliminary investigation showed that the aqueous extract has no action on such amino compounds as asparagin, glycocoll and benzamide and that it acts on urea with the production of ammonium carbonate under strictly antiseptic conditions.

The activity of the enzyme is measured by the amount of $(NH_4)_2CO_3$ formed.

The hydrolysis proceeds best under slightly acid conditions and the antiseptics, formalin. toluene, chloroform and salicylic acid have a harmful effect on the enzymic activity in the order named, the first mentioned being the most harmful.

In regard to its susceptibility to formalin this enzyme is identical with the urease of the soy bean as found by Wester (*Chem. Week blad*, **13**, pp. 663-677, 1916).

The enzyme is present in normal red gram seeds also but attempts to find urea were unsuccessful.

It is most active between 60° and 65°C. According to Wester (*loc. cit.*) this differs from the soy bean urease which is most energetic between 30° and 50°C.

VII. Summary.

The conclusions arrived at from this investigation are :—

(1) That an aqueous extract of the germinated dholl possesses the properties of an ereptase, amylase, cytase, maltase, sucrase, oxidase, lipase and urease.

(2) That no peptase is present in the normal seed and that the hydrolysis of the reserve protein takes place at a much later stage in germination ; whether this hydrolysis is due to protoplasmic activity or to the secretion of a separate enzyme in the course of germination is still doubtful.

I am indebted to Dr. W. H. Harrison, Government Agricultural Chemist, for the very kind encouragement and advice given throughout this investigation.

STUDY OF THE SUCROSE VARIATIONS IN SUCCESSIVE CANE JOINTS AS THEY ATTAIN MATURITY WITH SPECIAL REFERENCE TO THE DEATH OF THE LEAVES.

BY

T. S. VENKATARAMAN, B.A.,

AND

K. KRISHNAMURTI ROW, B.A.,

Assistants to the Government Sugarcane Expert, Madras.

THE main work at the Sugarcane Breeding Station, Coimbatore, is to raise a large number of sugarcane seedlings year after year, grow them to maturity and select the best of these as regards their botanical, agricultural, and chemical characters for propagation.

The sucrose value of any seedling is ordinarily ascertainable only when the seedling is ripe and is harvested. As this takes sometimes as long as twenty months from the date of germination, an attempt was made to get an earlier indication of it. Besides this, it would save heavy botanical and chemical work on undesirable seedlings to be able to detect the good ones before maturity.

So when the second batch of sugarcane seedlings to be raised in India, numbering over 2,000, were growing on the newly-acquired land at Coimbatore, we naturally became anxious to know of what value any particular seedling was likely to be at harvest. While we were able to get some idea, though a rather tentative one, of the botanical or agricultural characters, the sucrose value of the seedling was practically a sealed book. The question suggested itself : "May it be that some portion of the cane is ripe ?" If so an analysis of such a portion would give an indication of its sucrose value at harvest. After some futile attempts at analysing the basal one-third

or basal half of the cane, an analysis of that part which bears only dead leaves was inaugurated. The death of the leaf was a physiological process, and as such it was thought safer to consider that it corresponded to some definite process or the cessation of the process in the joint to which the leaf is attached.

Certain vigorously growing and obviously immature varieties were selected and portions of canes which bore only dead leaves cut and analysed (*vide* Table below).

TABLE I.

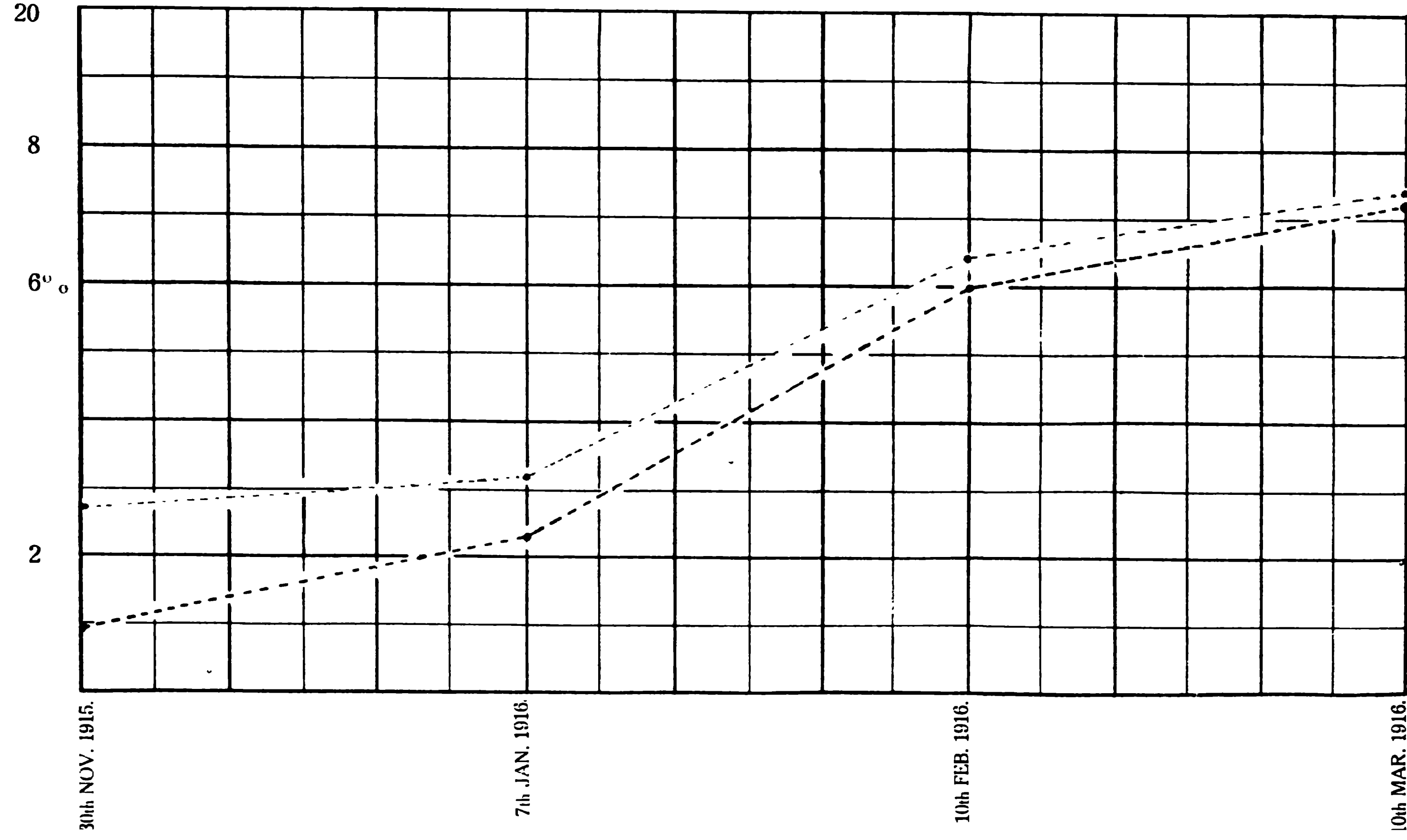
Name of variety	Number of joints bearing dead leaves	Sucrose per cent.
Yerra ..	5	16·68
Java	8	19·20
Vellai	Number of joints not recorded	17·93
Karun		14·77
J 213		18·52

This was an agreeable surprise, for not only were the figures quite different from what one should expect of obviously immature canes, but they further corresponded to the average sucrose contents of the respective varieties at harvest as ascertained from existing records. There was then apparently some use in the above analysis which we have called the "dead leaf" analysis, and so a series of fortnightly analyses of (1) Thick canes, (2) Thin canes, and (3) Seedlings was instituted fully to test the value of the above method. It was found, however, that the interference of various other factors—such as shooting, lodging, season and weather conditions, nature of the cane sampled "early" or "late" and possible interchange of food materials between mature joints—prevented this form of analysis from being fully useful.

The series, however, yielded a new method of ascertaining the ripeness of any variety or seedling. The ryot generally cuts the cane for the mill at a point beyond which it is soft and obviously useless for milling. Such an analysis we have called the ryot's sample analysis. We found that if the same cane or set of canes be sampled in both the ways described above, *viz.*, (1) as dead leaf

CHART

DEAD LEA AND RYOT'S SAMPLE ANALYSES OF HEM



sample and (2) as ryot's sample, and the resultant analysis figures compared with each other, they show great differences when the canes are immature, a gradual approximation as the canes advance in maturity and a practical coincidence at maturity (*Cf.* statements and curves).

TABLE II.

Dead leaf and ryot's sample analyses

(Figures in heavy type indicate analysis of dead leaf sample and those in ordinary type that of ryot's sample.)

JAVA 139

Date of analysis	Sucrose per cent.	Glucose per cent.	Co-efficient of purity
30th November, 1915	**15·61**	**0·39**	**87·8**
	12·67	1·11	80.9
7th January, 1916	**16·76**	**0·30**	**89·6**
	14·97	0·77	80·0
10th February, 1916	**17·64**	**0·23**	**91·1**
	17·01	0·30	89·2
10th March, 1916	**18·88**	**0·26**	**89·7**
	18·44	0·26	88·9

SARETHA.

Date of analysis	Sucrose per cent.	Glucose per cent.	Co-efficient of purity
30th November, 1915	**14·63**	**Below ·15**	**83·6**
	13·18	0·19	79·9
7th January, 1916	**16·12**	**Below ·15**	**85·7**
	15·07	Below ·15	84·9
25th January, 1916	**16·94**	**Below ·15**	**84·9**
	16·44	Below ·15	83·7
25th February, 1916	**18·49**	**Below ·15**	**86·6**
	18·06	Below ·15	85 8

TABLE II.—*Continued.*

HEMJA.

Date of analysis	Sucrose per cent.	Glucose per cent.	Co-efficient of purity
30th November, 1915	**12·69**	**0·25**	**84·7**
	10·85	0·45	78·7
7th January, 1916	**13·32**	**0·37**	**84·4**
	12·26	0·54	81·2
10th February, 1916	**16·33**	**0·23**	**87·9**
	15·96	0·24	87·3
10th March, 1916	**17·51**	**0·15**	**89·9**
	17·40	0·16	89·3
* KHAGRI.			
15th November, 1915	**11·39**	**1·00**	**77·7**
	9·78	1·43	71·6
14th December, 1915	**11·64**	**0·89**	**80·4**
	10·47	1·16	74·9
25th January, 1916	**12·59**	**0·67**	**80·0**
	11·67	1·00	75·6
10th February, 1916	**14·89**	**0·31**	**86·2**
	14·12	0·53	83·2

* Curve not drawn for this variety.

Note. In the light of the experience gained at the Cane Breeding Station on the errors caused by want of uniformity in the sampling of canes[1] and the existing literature on the subject (*vide* work by Leather[2] and Annett[3]), special attention was paid to uniformity in sampling, and in this the botanical knowledge was of considerable value. Dead leaf and ryot's samples of the same cane or set of canes were obtained for analysis as follows. The portion of the cane carrying only dead leaves was milled and half of the juice was set apart for the dead leaf analysis. The other half mixed with half

[1] Barber C. A., *Mem. Dept. Agri., India, Bot. Ser.*, vol. VIII, no. 3, 1916.
[2] Leather, J. W., *Mem. Dept. Agri., India, Chem. Ser.*, vol. III, no. 4, 1913.
[3] Annett, H. E., *Pusa Agri. Res. Inst. Bulletin* no. 49, 1915.

PERCENTAGES OF SUCROSE

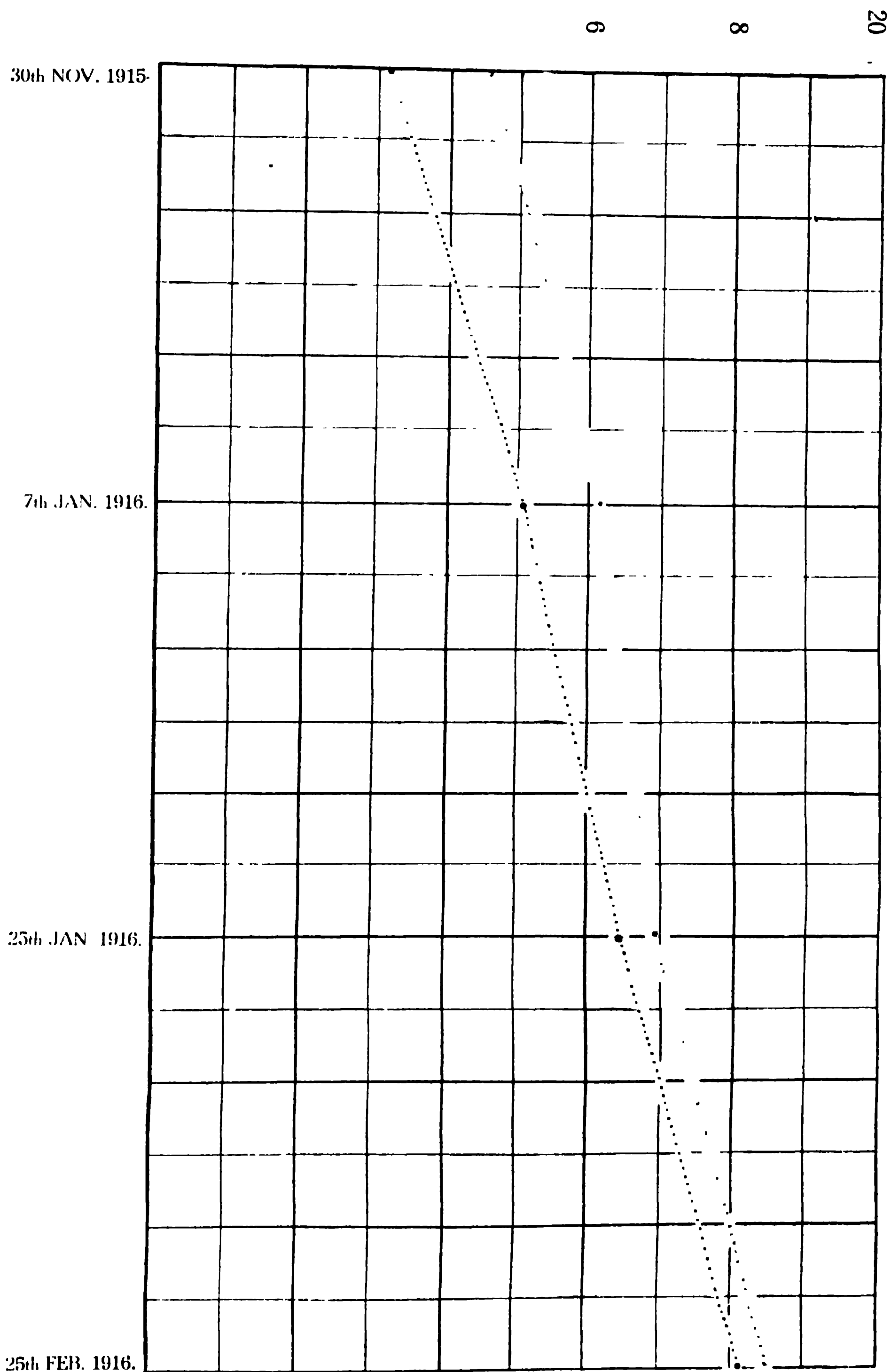
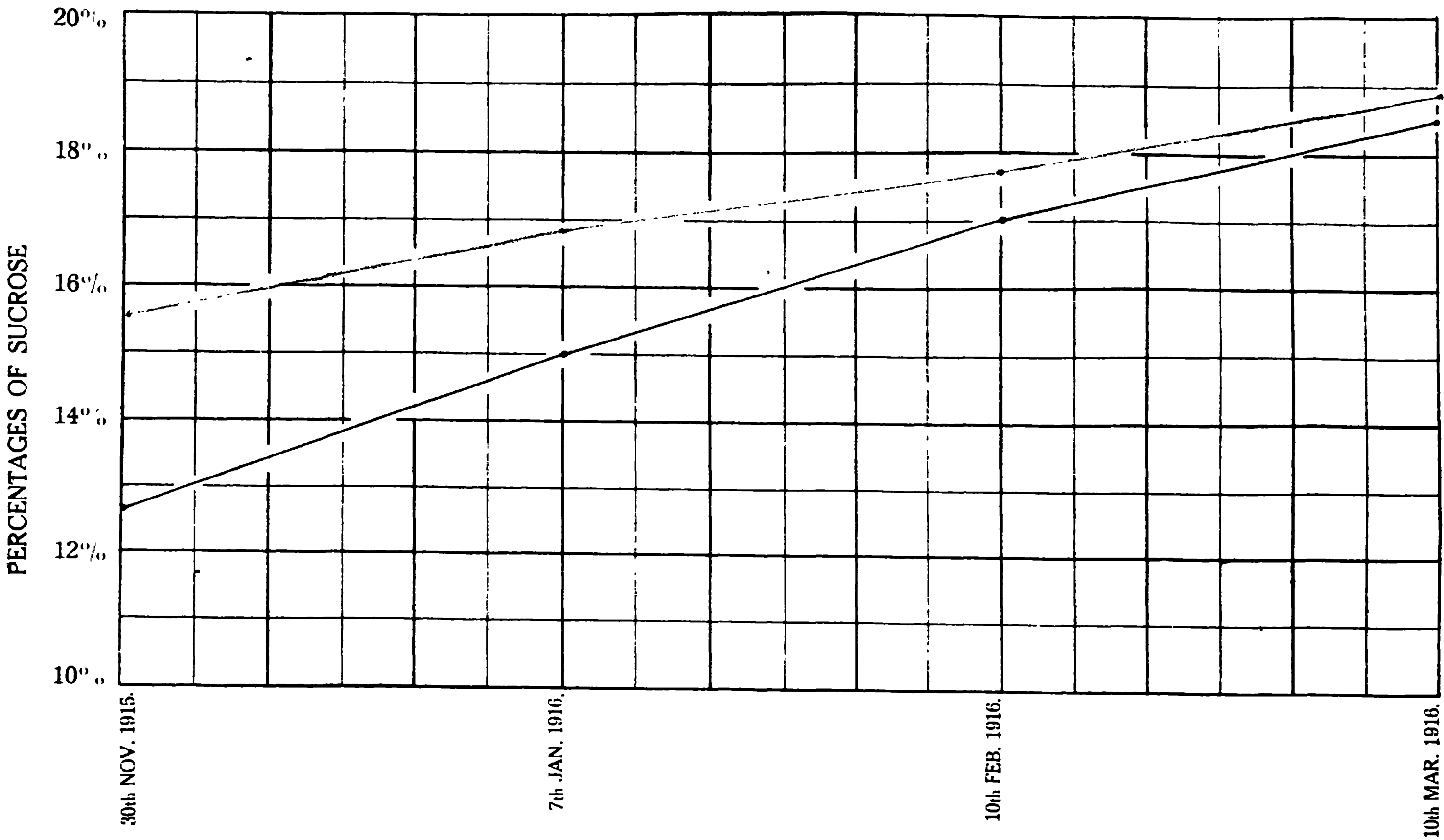
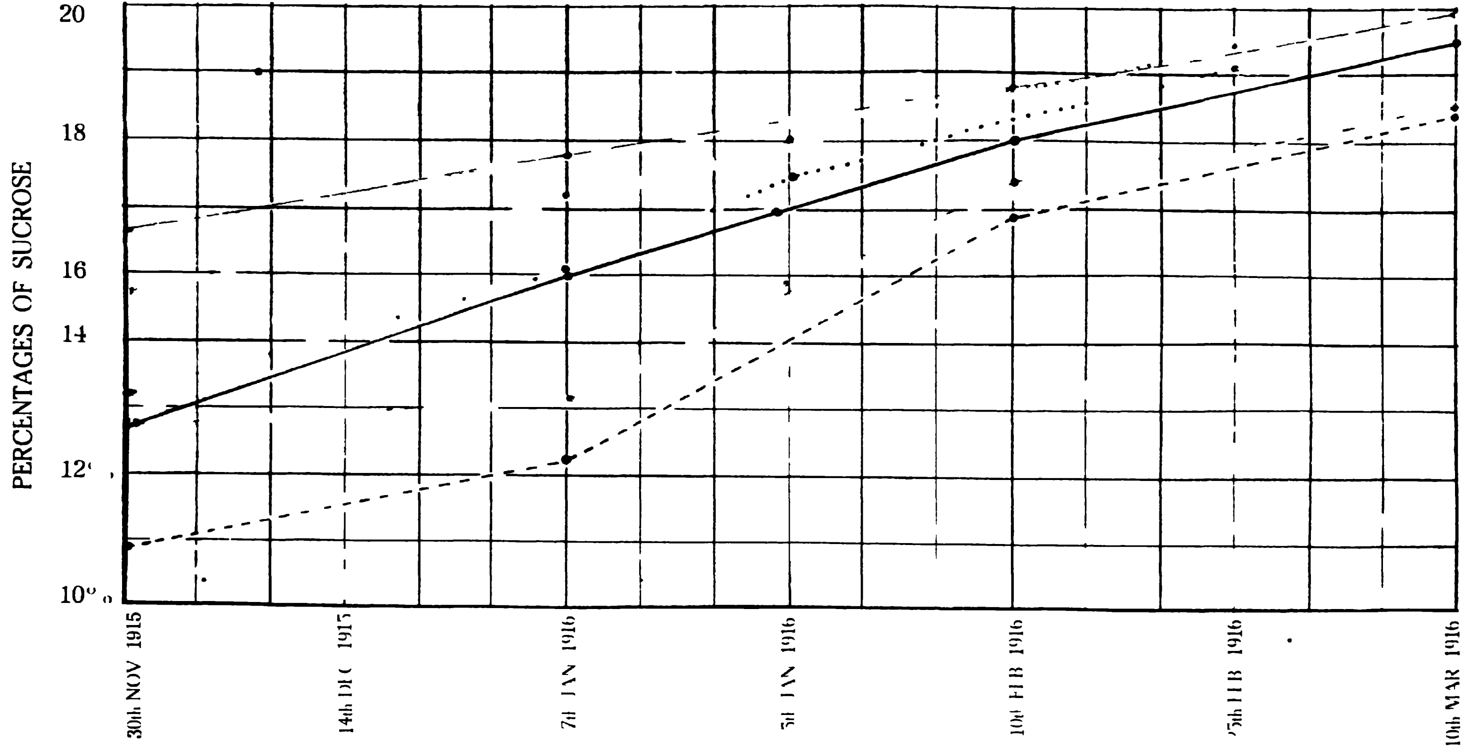


CHART III.

DEAD LEAF AND RYOT'S SAMPLE ANALYSES OF JAVA 139.




CHART IV
DEAD LEAF AND RYOT'S SAMPLE ANALYSES OF J 139, SARETHA AND HEMJA.
PERCENTAGES OF SUCROSE
20
18
16
14
12
10%
30th NOV 1915
7th JAN 1916
10th FEB 1916
10th MAR 1916

of the juice obtained by milling the part of the cane between the highest dead leaf and the point at which the ryot would cut the cane for the mill, yielded juice for the ryot's sample analysis.

Postulating some kind of maturity in that portion of the cane which carried only dead leaves it was difficult to understand the differences obtained between periodical dead leaf analyses of the same variety on different dates. In a few cases such differences were explicable on the score of shooting, lodging, weather conditions, etc., but it seemed probable that we were up against some larger phenomenon, and various possibilities suggested themselves. On the one hand the juice in the joints may undergo a further elaboration after the death of the leaf, and on the other the same juice may show a slight deterioration some time after the leaf is dead. To ascertain the exact nature of these changes, the system of sectional analyses, *i.e.*, dividing the cane into different sections of 3 or 4 joints each and analysing these separately, was inaugurated. The juices obtained in the sectional analyses were not enough for complete analysis, and so polariscope readings only could be recorded. The following are quoted from a large number of analyses, say about 200.

Table III.

Karun.

From Paddy Fields, Central Farm, Coimbatore, planted on 22nd May, 1915.

Canes from clump **A** *analysed on 23rd December*, 1915.

	I An unripe cane	II Cane riper than (I)	III Cane riper than (II)
Number of joints in ryot's sample	10	14	17
Number of dead leaf joints	6	9	10

I	Pol. reading	II	Pol. reading	III	Pol. reading
Basal 3 joints	81·2	Basal 3 joints	87·4	Basal 3 joints	86·0
Next 3 joints	73·2	Next 3 joints	86·4	Next 3 joints	86·8
		Next 3 joints	84·5	Next 3 joints	84·5
3 joints above dead leaf	51·5	3 joints above dead leaf	68·7	4 joints above dead leaf	60·6

Table III.—*Continued.*

Canes from clump **B** *analysed on 8th January,* 1916.

	I	II	III
Number of joints in ryot's sample	12	16	20
Number of dead leaf joints	8	11	15

I	Pol. reading	II	Pol. reading	III	Pol. reading
Basal 4 joints	**87·8**	Basal 3 joints	85·0	Basal 2 joints	81·8
Next 4 joints	72·6	Next 2 joints	**87·2**	Next 2 joints	86·0
		Next 3 joints	85·6	Next 2 joints	87·4
		Next 3 joints	80·8	Next 2 joints	**88·2**
				Next 3 joints	86·6
		2 joints above dead leaf	68·0	Next 4 joints	81·6
				4 joints above dead leaf	60·8

Canes from clump **C** *analysed on 31st January,* 1916.

	I	II	III
Number of joints in ryot's sample	13	18	21
Number of dead leaf joints	11	13	15

I	Pol. reading	II	Pol. reading	III	Pol. reading
Basal 3 joints	72·0	Basal 3 joints	84·6	Basal 2 joints	86·6
Next 4 joints	70·0	Next 3 joints	**89·0**	Next 2 joints	**89·4**
Next 4 joints	66·4	Next 3 joints	88·8	Next 3 joints	89·0
		Next 4 joints	85·2	Next 4 joints	88·4
				Next 4 joints	85·2
		4 joints above dead leaf	66·0	4 joints above dead leaf	67·8

Canes from clump **D** *analysed on 14th February,* 1916.

	I	II	III
Number of joints in ryot's sample	nil	19	24
Number of dead leaf joints	nil	16	20

II	reading	III	Pol. reading
Basal 4 joints	80·6	Basal 4 joints	78·2
Next 3 joints	83·8	Next 4 joints	85·0
Next 3 joints	**86·6**	Next 4 joints	86·8
Next 3 joints	86·6	Next 4 joints	**87·6**
Next 3 joints	81·8	Next 4 joints	82·6
3 joints above dead leaf	59·4	4 joints above dead leaf	60·4

TABLE III.—*Concluded.*

Canes from clump E *analysed on* 1*st March*, 1916.

	I	II	III
Number of joints in ryot's sample	nil	26	22
Number of dead leaf joints	nil	20	18

I	II	reading	III	Pol. reading
nil	Basal 4 joints	.. 82·2	Basal 3 joints	.. 33·6
	Next 4 joints	.. 86·4	Next 3 joints	.. 50·0
	Next 4 joints	.. **87·8**	Next 3 joints	.. 63·2
	Next 4 joints	.. 87·1	Next 3 joints	.. 75·8
	Next 4 joints	.. 80·4	Next 3 joints	.. 86·2
			Next 3 joints	.. **87·6**
	Four joints above dead leaf	56·2	Four joints above dead leaf	71·4

N. B.—Note the sudden drop in the polariscope readings immediately above the dead leaf joints.

JAVA 33A.

FROM PADDY FIELDS, CENTRAL FARM, COIMBATORE, PLANTED ON 24TH APRIL, 1915.

Analysed on 18*th March*, 1916.

	I	II	III
Number of dead leaf joints	10	16	19

I	Pol. reading	II	Pol. reading	III	Pol. reading
Bottom 5 joints	.. 88·2	Bottom 3 joints	.. 92·0	Bottom 3 joints	.. 85·6
Next 5 joints	.. 84·1	Next 3 joints	.. **93·6**	Next 3 joints	.. 92·0
		Next 3 joints	.. 93·2	Next 3 joints	.. **93·2**
		Next 3 joints	.. 91·4	Next 3 joints	.. 91·6
				Next 3 joints	.. 89·4

POOVAN.

FROM VEDAPATTI VILLAGE, COIMBATORE, PLANTED IN MARCH-APRIL, 1915.

Analysed on 29*th February*, 1916.

	I	II	III
Number of dead leaf joints	18	21	21

I	Pol. reading	II	Pol. reading	III	Pol. reading
Bottom 2 joints	.. 76·6	Bottom 7 joints	.. **79·8**	Bottom 3 joints	.. 76·8
Next 2 joints	.. 62·4	Next 7 joints	.. 78·2	Next 3 joints	.. 77·2
Next 2 joints	.. 62·4	Next 7 joints	.. 70·4	Next 3 joints	.. 78·2
Next 3 joints	.. 63·6			Next 3 joints	.. **80·2**
Next 3 joints	.. 61·0			Next 3 joints	.. 79·2
Next 3 joints	.. 57·6			Next 3 joints	.. 71·8
Next 3 joints	.. 53·8				

From the statements it is found that—

(1) In a very immature cane the highest sucrose content is found in the lowest section.

(2) As the cane advances in maturity this region of the highest sucrose content gradually moves upwards.

(3) If different canes of the same variety are analysed on different dates, the highest sucrose contents obtained on these dates are practically identical. In the analyses quoted above of Karun the highest sucrose readings on different dates (printed in heavy type in the Tables) vary from 86·6 to 89·4. The maximum difference is thus 2·8 or 0·7 sucrose. This difference, it will be conceded, is little, especially when the variations introduced by the difference in the number of joints taken for sectional analyses and possible inequalities in milling are considered.

(4) A cane left growing in the ground after it has attained maturity shows rapid deterioration at the basal joints. This is still better brought out by a Brix determination of two different over-ripe Madras seedlings of about 22 months old (*Cf.* Table below).

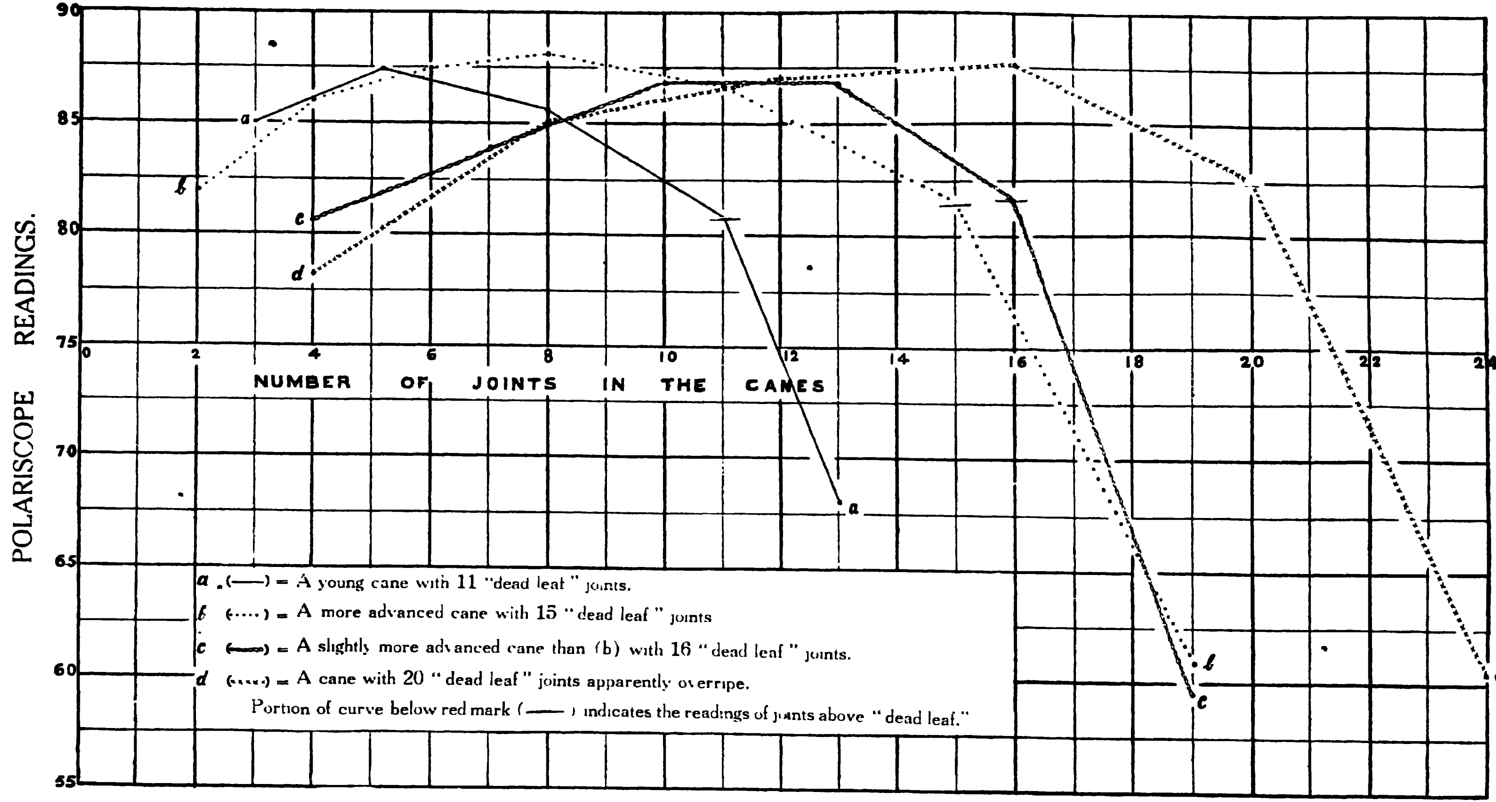
M. 4112	Top one-third	.. 22·80	per cent.	(Brix)
	Middle one-third	.. 19·80	,,	
	Bottom one-third	.. 14·00	,,	
M. 2989	Top half	.. 22·33	,,	
	Bottom half	.. 17·71	,,	

(5) The highest sucrose reading obtained by sectional analyses of any particular variety probably represents the highest sucrose content that the variety is capable of containing under the given conditions, and this we have called the "sucrose index" of the cane. It is claimed that this is fairly constant for each variety or seedling and will enable a comparison to be made between different seedlings even when they are immature.

We are greatly indebted to Dr. C. A. Barber for advice and for freely affording facilities to carry on the work described above.

CHART V.

4 CANES KARUN AT DIFFERENT STAGES OF MATURITY.



THE INDIAN SPECIES OF *ISEILEMA*.

BY

R. S. HOLE, F.C.H., F.L.S., F.E.S,

Forest Botanist, Dehra Dun.

WHEN Mr. D. O. Witt, Deputy Conservator of Forests, was preparing his List of Fodder Grasses found in the Berar Forest Circle of the Central Provinces (published, Allahabad, 1911), he found it impossible to deal satisfactorily with the local species of *Iseilema,* a genus which includes what is probably the most valuable forest fodder grass in the Indian peninsula. Mr. Witt recognized in the field two obviously distinct plants which, moreover, differed greatly in their economic value. On sending specimens of these to a herbarium, however, he was given the same name, *viz., I. laxum* for both plants. Still adhering to his opinion that the plants were really distinct species Mr. Witt provisionally dealt with them as follows—

No. 57 *I. laxum*, Hack.

No. 59 *I.* sp.

and the matter was referred to the Forest Botanist for study.

During the last few years, therefore, the Forest Botanist has made a detailed study of the Indian species as regards—

(1) The original types in London and Kew.

(2) The herbarium material available in London, Kew, Calcutta, and Dehra Dun.

(3) The living plants grown from seed at Dehra Dun.

This study has shown that Mr. Witt's plants are—

No. 57. *Iseilema anthephoroides*, Hack.

No. 59. *I. laxum*, Hack.

and also that the confusion between these two species has hitherto been almost universal. In every herbarium which has been visited specimens of *I. anthephoroides* misnamed *I. laxum* have been found. This confusion has been caused by the inadequate and to some extent erroneous descriptions of the species which have been hitherto available.

The spikelets which constitute the inflorescence in this genus are arranged in small clusters, each cluster springing from a boat-shaped leaf called the *spathe.* At the base of each cluster are normally 4 stalked ♂ spikelets arranged in a ring which are called the involucral spikelets. In the centre of these spikelets is the main axis of the inflorescence, at the apex of which are a sessile fertile ⚥ spikelet and two stalked ♂ spikelets, the lower nodes of the axis, if any, carrying each one sessile ⚥ and one stalked ♂ spikelet.

In the year 1889, Hackel first described the species *Iseilema anthephoroides* in Vol. VI of De Candolle's *Monographs of the Phanerogams* and by his specific name he emphasized the fact that he regarded the remarkable short, stout, curved pedicels of the involucral spikelets as the primary characteristic of the plant. No definite measurements, however, were given to indicate precisely the length and width which distinguish the pedicels of this species from those of *I. laxum.* Hackel also regarded the absence of tubercles on the keel of the spathe and floral leaf as a character of primary importance whereas, in this species, the tubercles may be present or absent in one and the same plant. Hackel also overlooked the very important character afforded by the hairs on the back of glume I of the ⚥ spikelet at the base.

As a result of the present work the Key shown below has now been drawn up and it is believed that this will render the identification of the Indian species of this genus easy in the future.

ISEILEMA.

Glume I ⚥ spikelet dorsally adpressed hairy at base and ciliate on margins in basal ½.
Length of pedicels of involucral spikelets not exceeding their width at apex .. .. 1. *I. anthephoroides*, Hack

Glume I ⚥ spikelet glabrous dorsally at base and on margins in basal ½:

Length of pedicels of involucral spikelets often not exceeding their width at apex, ⚥ spikelet 0·24-0·32 *in.*, spathe often tubercled on keel .. .. 2. *I. argutum*, Anderss.

Length of pedicels of involucral spikelets exceeds their width at apex, ⚥ spikelet 0·09-0·24 *in.*

Spathe and upper floral leaf not tubercled on keel .. .. 3. *I. laxum*, Hack.

Spathe and upper floral leaf tubercled on keel .. .. 4. *I. Wightii*, Anderss.

In general appearance *I. anthephoroides* is a stout plant of low growth with short leaves, while *I. Wightii* is a tall slender plant with long leaves, *I. laxum* being more or less intermediate in this respect between these two species.

I. laxum is a perennial and is generally acknowledged to be the best forest fodder grass in central and south India, while *I. anthephoroides* is an annual, a much smaller yielder and obviously an inferior fodder plant.

It may now be said that systematic work of the kind described above is of no economic importance and should form no part of the duties of a so-called Economic Botanist. To some extent this opinion appears to be due to ignorance of the methods, difficulties, and scope of systematic work. For a considerable period systematic botany held the field in India. The idea then gained ground that a great deal of systematic botany dealt with species of no value and this eventually led to a strong swing of the pendulum in the direction of so-called economic botany. This resulted in a provision for the economic study of agricultural plants at the Pusa Research Institute and of forest plants at the Dehra Research Institute. The improvement of agricultural crops does not fall within the scope of ordinary systematic botany which deals with wild species.

As regards forest plants, however, it is perfectly clear that sound progress in economics is impossible without an extended study of systematics. The non-botanist is apt to think that, with the publication of the Flora of British India and the formation of good herbaria at Calcutta, Dehra Dun, and elsewhere, systematic work has been completed and has no further scope in India. This, however, is far from being the case. Systematic work is at first necessarily tentative and when, in India, we undertake the detailed study of species in connection with the exploitation of the commercial products yielded by them, which necessitates the identification of large numbers of individuals occurring over extensive areas and the separation of all individuals belonging to species of commercial value from those which belong to valueless but nearly related species, we are forced to recognize the fact that the descriptions in the Floras drawn up from a few often imperfect specimens are more or less fragmentary and not infrequently misleading.

Unless such descriptions are revised, incorrect identifications must occur and these will cause not only confusion but financial loss, which may be considerable, by obscuring the value and retarding the exploitation of valuable species. In the case of the *Iseilemas* it has been shown how confusion with *I. anthephoroides* has tended to obscure the outstanding value of the fodder grass *I. laxum* and a similar state of things is known to exist in the case of commercial timber trees and forest grasses utilized in the manufacture of paper-pulp. A thorough study of indigenous medicinal plants would almost certainly bring many other cases to light and there can be no doubt that there is great scope in India for an extended study of the systematic botany of forest species which is essential for economic development.

As regards the scientific importance of a detailed study of species attention is directed to its bearing on that question of perennial interest to scientists, *viz.*, the origin of species. The detailed study of species not only accurately defines the specific groups, which is an essential preliminary to a study of their origin, but may also indicate the lines on which our experiments should

be organized to obtain the desired proof regarding any particular theory of origin.

Species are commonly held to have originated in two principal ways :—

(1) By the progressive accumulation, under the guidance of selection, of small variations or of mutations, the actual cause of which is unknown but which possibly is to be found in the stimulus supplied by the environment.

(2) By the intercrossing of existing forms.

Method (1) does not lend itself readily to experimental treatment whereas method (2) can be tested in this way.

If an abstract is made of the important characters of the species of *Iseilema* it will be seen that *I. Wightii* and *I. anthephoroides* constitute two strongly divergent types of possibly different genetic origin.

In the allied genera, *Pseudanthistiria, Anthistiria,* and *Iseilema,* differences in the development of the involucral spikelets usually constitute characters of generic importance. Now in the raceme of *Iseilema Wightii* there is a tendency towards continued apical development coupled with occasional abortion of the involucral spikelets whereas in *I. anthephoroides* we have precisely the reverse, *viz.*, a short raceme with very strong development of the involucral spikelets and frequent abortion of the apical spikelets.

Possibly connected with this characteristic is the tendency towards length combined with slenderness which we find manifesting itself in the culms, leaves, and inflorescence of *I. Wightii* whereas in *I. anthephoroides* these parts are characterized by their shortness and stoutness. On the other hand the remaining species *I. argutum* and *I. laxum* are more or less intermediate between the two extremes and exhibit an intermingling of the characteristics of these extremes such as might possibly have been produced by the intercrossing of individuals belonging respectively to the species *I. Wightii* and *I. anthephoroides ;* the merging of some characters giving an intermediate result and the dominance of others producing

a resemblance sometimes to one and sometimes to the other species.

Thus as regards habit, length of culms, and length of pedicels *I. laxum* resembles *I. Wightii*, whereas as regards length of leaf, hairiness of panicle nodes, length of peduncle and ⚥ spikelet *I. laxum* is intermediate between *I. Wightii* and *I. anthephoroides*. On the other hand *I. argutum* is intermediate as regards length of leaf, hairiness of panicle nodes and length of pedicels, whereas it resembles *I. anthephoroides* in tubercles on floral leaves and spathes and length of peduncle. If *Iseilema argutum* and *I. laxum* owe their origin to the intercrossing of individuals belonging to the primary species *I. Wightii* and *I. anthephoroides*, we should expect to find the secondary species in or immediately adjoining those regions where the supposed parents are known to exist. *I. argutum* is confined to Burma and in its area one of the suggested parents (*I. Wightii*) is known to occur but the other *I. anthephoroides* has not yet been reported. Considering how little we know about the Burmese grasses, however, it is quite possible that *I. anthephoroides* does exist in Burma. *I. laxum*, on the other hand, is practically confined to the area in which both the suggested parents are known to exist. In the case of this genus, therefore, it is possible that experimental crossings of *I. Wightii* and *I. anthephoroides* may indicate the origin of the two species *I. argutum* and *I. laxum*. The actual demonstration that certain species such as these examples can be produced by intercrossing, however, would naturally not prove that this was the case with all or even the majority of species and it is probable that existing species have originated in different ways.

In conclusion the chief points emphasized in this paper may be summarized as follows :—

(1) The necessity for an extended study of systematic botany in India.

(2) The economic importance of a detailed study of species in preventing the adulteration of valuable products with inferior material.

(3) The scientific bearing of a detailed study of species on the question of the origin of species as regards the accurate definition of the specific groups and an indication of the lines on which experiments may be organized for the purpose of demonstrating their mode of origin.

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